A CHAPTER IN AMERICAN EDUCATION

RAY PALMER BAKER

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RENSSELAER POLYTECHNIC INSTITUTE
1824–1924

BY RAY PALMER BAKER

ENGINEERING EDUCATION

A HISTORY OF ENGLISH-CANADIAN LITERATURE TO THE CONFEDERATION

Its Relation to the Literature of Great Britain and the United States

THE PREPARATION OF REPORTS

Engineering, Scientific, Administrative

SAM SLICK

Edited with a Critical Estimate and a Bibliography

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RENSSELAER POLYTECHNIC INSTITUTE
1824–1924

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PROLOGUE

In the beginning I planned this sketch—for it is little more—as a slight memorial of the hundredth anniversary of the foundation of Rensselaer Polytechnic Institute. Before I had delved far in its history, however, I realized that I was dealing with a subject of no parochial concern; that, for half a century, the institute was one of the intellectual centres of America; and that no one can understand the growth of educational facilities for women, the development of agriculture, the transformation of the college of liberal arts, the emergence of the graduate school, or the progress of science and technology who is not familiar with conditions in Troy during the second and third quarters of the nineteenth century. I have tried, therefore, to marshal the achievements of Amos Eaton and Stephen Van Rensselaer in proper perspective and to indicate the national significance of much that has seemed of mere local interest.

Few historians are aware that the traditions fostered by the Institute had become so generally recognized by 1850 that, with others, several of its graduates—James Hall ('32), the "father of American stratigraphy"; George Hamill Cook ('39), a naturalist of note, who afterward became vice-president of Rutgers College, and Ebenezer Emmons ('26), the founder of agricultural science in the United States, incorporated at Albany a university which they believed would challenge, in due time, the supremacy of Berlin. Among the scholars at Harvard who in "utter disgust at the way things were done in Cambridge," offered to associate themselves as professors in this great enterprise in the Capitol District were Louis Agassiz, professor of natural history; Joseph Lovering, professor of mathematics; Benjamin Pierce, professor of astronomy, and Jeffries Wyman, professor of anatomy. From Yale were to come such leaders as James Dwight Dana, professor of natural history, and John Pitkin Norton, professor of agricultural chemistry and vege-

table and animal physiology. Among others who were to lend their aid were Ormsby McKnight Mitchell, professor of astronomy in Cincinnati; Josiah Dwight Whitney, afterward professor of geology at Harvard, and Benjamin Hall Wright, of West Point. Though the institution as a whole never materialized for lack of funds; though Agassiz, Cook, Emmons, Hall, Mitchell, and Norton were evidently the only members of the group who actually delivered lectures; and though the Dudley Observatory, established by Pierce, Mitchell, and Norton, is to-day the only monument of this attempt to found a national university with generous provision for research, the proposal is illustrative of the influence which Rensselaer, through its curricula or its alumni, has exerted throughout the Americas.

For obvious reasons I have not, except in the case of those who have been canonized, as it were, by the dormitories erected in their honor, referred specifically to the graduates who to-day are adding to the fame of their

alma mater. Nor have I attempted to trace the careers of the students—six or seven thousand in all—who, in the last century, did not proceed to a degree but who, in some instances, left their mark on the civilization of their time.

R. P. B.

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CHAPTER I

ORIGINS AND AIMS

In the history of education in the United States there have been two outstanding events—the founding of the college which is the nucleus of Harvard University and the establishment of the school which has become Rensselaer Polytechnic Institute. Though it may seem strange to link in this way two institutions one of which—with less than one-third as many students—is only one-third the age of the other, each began a tradition in literature or science of immeasurable consequence. Moreover, since the courses at Rensselaer between 1824 and 1834 dealt with both the farm and the factory, it was from one point of view—though its life as such was short—the first college of agriculture as well as the first college of technology. In addition, it anticipated in many ways the preliminary training now required for pro-

fessional study; and, for those who had already enjoyed a liberal education, it provided many of the advantages of a graduate school. Nor were its activities confined entirely to men. For these reasons—because of its influence upon the position of women, because of its contribution to rural life, because of its reaction upon academic routine, because of its provision for advanced and, in the light of the time, highly specialized research —because of these reasons and, particularly, because of its primacy as the first college devoted to the sciences which has existed continuously for a hundred years, its history is a subject of universal interest.

The qualification in the last sentence is necessary because, in point of time, it was not the first institution of its kind in the United States. In half a dozen colleges instruction in the sciences had been offered before 1800. In others, provision of an elementary character had been made by 1820. Moreover, as President Ricketts has explained in the second edition of his admirably

comprehensive *History of Rensselaer Polytechnic Institute*,[1] the Gardiner Lyceum, which survived for a decade, was opened in 1823. By 1824, therefore, many educators evidently realized that a change in policy was imperative. In fact, recognition of the need seems to have been fairly general. At Cambridge, Joseph Story, chairman of a special committee appointed at the instance of George Tichnor, presented a report advocating the establishment of a department in which students would be permitted "to pursue particular studies to qualify them for scientific and mechanic employment and the active business of life." When a group of citizens met at White's Hotel, in Easton, to discuss the organization of a college, they voted to include in the curriculum not only the "dead languages . . . usually taught" but also "civil and military engineering." Neither Harvard nor Lafayette, however, was able to carry out its plans until, a generation later, it was able to draft the graduates

[1] New York, 1895, 1914.

of the Institute who had been trained in the disciplines which these gentlemen had advocated. Though their proposals led to no immediate results, the current opinion that Rensselaer sprang meteor-like from pedagogical chaos does not appear to be justified by the facts. Like every striking development, it was the climax in a process of evolution. It was unique only in finding a benefactor and a leader who accomplished what others had merely suggested.

The first of these two men was Stephen Van Rensselaer. President Ricketts has called attention to the example set by Count Rumford in the establishment of the Royal Institution. He has also pointed out that Van Rensselaer may have been stimulated by its success. At any rate, in a letter to Samuel Blatchford announcing the foundation of the school, the latter used the terminology of Thompson's prospectus,—"the application of science to the common purposes of life." Whether this phrase was borrowed or not, it describes exactly the object which

he had in view. What he planned was an institution to provide teachers to instruct "the sons and daughters of farmers and mechanics" in "agriculture, domestic economy, the arts, and manufactures." And this idea he seems never to have dropped. In due time, he wrote, every district might enjoy "such a course of instruction about once in two or three years." Moreover, in 1827, evidently at his instigation, the faculty were authorized to establish branches in any part of the state which could make adequate provision for them. Later in the same year he suggested to Blatchford the propriety of offering the school to the legislature. Since nothing came of this suggestion, he announced that he would meet the expenses of a student from every county on condition that those accepting his aid should return to their homes to teach for one year. Afterward, also, he adopted the same plan in special cases. The whole scheme, therefore, bore a definite relation to Van Rensselaer's position in the community.

As Patroon of Rensselaerwick, he was naturally interested in the progress of the three counties into which it had been divided. Consequently, when the Central Board of Agriculture was organized, in 1820, he was elected president. When it engaged Amos Eaton to conduct an agricultural survey of the district, he provided the necessary funds. Moreover, as a member of Congress, during this time, he served as chairman of the Committee on Agriculture. Under these circumstances, it is not difficult to understand his attitude. There is no reason to believe that it was not immediately utilitarian. Except in its most rudimentary form, the Dutch settlers on the Hudson had never been impressed by the value of education for its own sake. According to William Smith, the historian of New York, there were in the province in his youth only fifteen laymen who had enjoyed a collegiate training; and they were mostly graduates of Yale or Cambridge. As a class the comfortable burghers east of the Palisades were "so intent upon

gain" that they were seldom disturbed by the stings of intellectual ambition. At any rate, when the establishment of a college was mooted in New York, they objected strenuously to any arrangement which would require their support. In the end, it was founded privately by English families whose sons had been educated in Massachusetts or Connecticut. From Van Rensselaer's paternal ancestry, therefore, little information can be derived. The source of his interest in education evidently lay elsewhere. Since his father died early, the influence of his mother, a daughter of Philip Livingston, must have been especially powerful. To her, doubtless, he owed his matriculation at Princeton and his graduation from Harvard. Nevertheless, in spite of these advantages, his eyes seem to have been fixed primarily upon the nine hundred farms which he had brought under cultivation on his estate. Useful as his life unquestionably was, it does not appear to have been marked by either force or originality. Neither as soldier nor statesman did

he impress his generation as especially virile or prophetic. As his portrait indicates, he seems to have been a kindly, well-intentioned gentleman differing little from others of similar training and environment except in his wise, generous, and untiring devotion to the institution which he founded.

Amos Eaton, however, was an original genius of profound and far-reaching intellect. Local tradition, well authenticated, credits him with the inception of the Institute; and certainly Van Rensselaer's letter announcing the organization of the school bears evidence of his hand. In fact, until 1840 his influence was supreme. His career is therefore a matter of interest. Educated at Williams, the first of its alumni to achieve distinction, he studied at Yale under Benjamin Silliman, who lived to see his pupil transcend the barriers which had inhibited his labors in New Haven. Returning to Williamstown in 1817, he conducted a series of extra-collegiate lectures on botany, geology, and mineralogy which were attended by all the seniors and

juniors and by all but four of the sophomores and freshmen. So popular were these lectures that the undergraduates of their own volition published the manuscript of the first group. Because of the success, Eaton determined to offer experimental courses wherever he could find an audience. As a result, over seven thousand students—in his day, an unprecedented number—attended his classes in natural history. In addition to those treated in this sketch, many of the most eminent scientists of the day—pioneers like James Dwight Dana, professor of natural history at Yale; Chester Dewey, professor of chemistry at Rochester; Asa Gray, professor of natural history at Harvard; Joseph Henry, professor of natural history at Princeton; Albert Hopkins, professor of astronomy at Williams, and John Torrey, professor of chemistry at Columbia—began their work under his direction.

Now that it is possible to view his achievements in true perspective, it is clear that he is one of the great figures in the history of

science in the United States. Though his botanical nomenclature has often been modified, the value of his researches has become increasingly apparent; and recent investigations by the Geological Survey have strengthened his position as the "father of American geology." Nevertheless, striking as were his discoveries and monographs, they were surpassed by his services to the cause of education. The first to introduce field work and laboratory routine into the American college, the founder, in Troy, of the first popular museum of natural history, a pathfinder in many fields, he illuminated by his personality the city which he made his home. Devoted to the practical affairs of life, he still worshipped truth for its own sake; and it was this rare union of intellectual curiosity and rough-and-ready utilitarianism which made Rensselaer at once a centre of "pure" scholarship and a school of engineering.

As Van Rensselaer's letter shows, he planned to establish in Troy an institution to serve the needs of young women as well as

young men. The inclusion of "domestic economy" in the list of subjects to which the natural sciences were to be applied is proof that he contemplated a type of school which did not emerge until the twentieth century. Why the authorities did not carry out this part of the scheme, it is impossible to say. Since the students at Rensselaer lived and studied in the same building; since both sexes could not be accommodated under such circumstances; and since the Patroon found the burden of one establishment increasingly irksome, it is fairly obvious that the expense of setting up a complementary organization was responsible for the abandonment of half the programme suggested by the prospectus. Certainly there was no lack of sympathy among those who were connected with the Institute. In spite of the fact that they did not attempt to provide a complete curriculum, they nevertheless helped to advance the education of women in the United States. Eaton especially was a persistent advocate of their claims. So far as it is pos-

sible to judge from the records which have been preserved, his influence was due to his knowledge of botany and chemistry—two subjects which evidently appealed to the taste or imagination of his auditors.

As a botanist, he had translated Richard's *Dictionary;* he had published half a dozen original treatises; he had established the Botanical Institution at Catskill; and he had appeared before the New York State Legislature at the invitation of Governor Clinton, who had attended some of his public lectures. It was through these lectures, delivered at Amherst, Northampton, and elsewhere, that he influenced a number of women who were to become conspicuous in the first half of the nineteenth century. "You can generally," he remarked, "persuade ladies to go out in small parties to the nearest open fields" and collect plants for the next day's study. And evidently many did go; for, in 1819, Jane Welsh, who had been a member of his class in Northampton, where he conducted the first courses in science ever opened to women,

issued her *Botanical Catechism.* Ten years afterward Almira Lincoln, a sister of Emma Willard, published her *Familiar Studies in Botany*, a volume based upon Eaton's manuscripts. Finally, in 1840, Laura Johnson, who had been a member of his family for five years, put forth, under his supervision, the second edition of her *Botanical Teacher*, a companion to the eighth edition of Eaton's *North American Botany.* So far as I am aware, the movement culminating in this literature—a movement designed to "promote knowledge and magnify the Creator"—was the first of its kind on the continent. Nor was it limited by any means to botany. Among Eaton's students at Northampton was Mary Lyon, the founder of Mount Holyoke College. Apparently, if her letters can be accepted as evidence, she was more interested in chemistry than in botany. At any rate, she became an ardent disciple of the senior professor, following him to Troy, and, like Laura Johnson, living in his home, "as he could tell me many things that would

be useful to me." "Accordingly," she confided naïvely in a letter to one of her friends, "I packed up all as soon as possible and arrived here this morning." Through such informal contacts the faculty of the Institute exerted no little influence upon the development of educational facilities for women.

All their contacts, however, were not so informal. Emma Willard, who had been associated with Mary Lyon, relied upon them for instruction in the sciences at the Troy Female Seminary, now, under its modern name, the oldest school for girls in the United States. Moreover, though the Institute itself never offered any courses for women, Eaton apparently did so "in his private capacity." In fact, he seems to have developed some kind of organization; for, in 1828, the authorities announced that "a lady, well qualified for the duty," would conduct experimental courses in chemistry and natural philosophy similar to those "proposed for gentlemen," and, in 1835, he requested an

examination in "practical mathematics" for a class of eight. As late as this, ten years after the Institute had been established, he reiterated in the synopsis of one of the courses in the curriculum his belief that the failure of women in the sciences was due to incompetent teachers and poor text-books and not to "the perversion of female genius" to which it was usually credited. Since he held such advanced views, it is small wonder that educators like Mary Lyon and Emma Willard turned to Eaton for encouragement and advice.

Though the Institute was never able to carry out its plans regarding "domestic economy," it made some provision at least for agricultural education. Before its establishment there had been proposals at Columbia and Pennsylvania for departments adapted to the needs of farmers; but it organized and maintained, for nearly ten years, the first curriculum of this kind. It was, therefore, the first school of agriculture in the United States, antedating the Michigan State Agri-

cultural College, founded in 1857, by almost thirty-five years. Because of this fact, its methods are historically important. So far as can be gathered, instruction was conducted in classrooms, laboratories, and field gardens, and on "well cultivated farms." In the classrooms such topics as plant and animal physiology were treated at length. The laboratories were devoted to the analysis of soils, manures, plants, and vegetables and to the dissection of animals. In the school gardens, students were required to make "experiments upon nutritious matter proper for vegetables," or, again, to apply "active substances," such as acids and alkalies, to the plants provided. Moreover, they were expected to "observe the operations of the agriculturists on the school farms" and the "progress of cultivated grains, grasses, fruit trees. . . ." In addition, they were supposed to learn the "art of inculcating and engrafting trees, transplanting by roots . . . and pruning. . . ." In view of the complementary studies which were provided, it is clear

that the Institute offered a useful training to the "sons of farmers" who might apply to it. However, agriculture, which stood first in 1825 in the list of vocations to which the natural sciences were to be related, stood last in 1847 and, a little later, disappeared altogether. Although the life of Rensselaer as an agricultural college was thus of short duration, it made possible the work of men like Ebenezer Emmons ('26), who established in New York the first department of agriculture; Asa Fitch, Jr. ('27), "the father of economic entomology" and the first official entomologist of the United States; James Hall ('32), who helped to pave the way for the Iowa State Agricultural College; Ezra Slocum Carr ('38), the first professor of chemistry as applied to agriculture in the Universities of Wisconsin and California; and George Hamill Cook ('39), director of one of the earliest experiment stations. Even to agricultural education, therefore, the Institute made no slight contribution.

On the other hand, its effect upon the

academic colleges is by no means certain. Eaton, whose mind ranged far beyond that of most of his contemporaries, and who evidently wrote most, or all, of the early notices, attacked their methods without stint. "The aspiring energies of youth," he remarked, "had been chained down to a kind of literary bondage." Their "native curiosity" had been stifled, and their masters had depended on "the rod in their early years" and on "fines, rustications, and expulsions" in their latter. All this he would change. There was no reason, he insisted, why interest could not be "successfully excited" in "every department of human learning" if "things, not words," were studied. For this reason he advocated the introduction of experimental methods in every field of instruction. As might be expected, he incurred the hostility of conservative educators. To-day, when the sciences are universally recognized, it is hard to understand the bitterness of their attack. Bitter, however, it must have been; for Eaton, on more than one occasion, referred

to the pain occasioned by their attitude. Though this attitude lingers in a few institutions which have not yet learned that tolerance is the finest fruit of scholarship, Eaton lived to see his ideas "borrowed" by many of the colleges which had been the most persistent critics of his scheme. Whether the example set by the Institute reacted as powerfully as he believed, it is evident that it offered to students preparing for the established professions a group of subjects—mathematics, the sciences, public speaking, law, literature, rhetoric, composition, government, political economy, and philosophy—that to-day, after the lapse of a hundred years, represents more accurately than any other curriculum of 1824 the type which has taken shape in the average college of liberal arts. In a crude but, nevertheless, prophetic manner, Eaton undoubtedly anticipated the correlation of the natural and social sciences which has become so characteristic an element of modern education. Few educators—even the most conservative—would now care to

challenge his conception of the college in its relation to life and learning.

Though it is possible—notwithstanding the number of students who have entered the church, the law, dentistry, or medicine—that his conception of this relationship did not crystallize into an integrated unit, there can be no doubt that he envisaged clearly the modern graduate school with its professional standards. Within a decade he made Rensselaer—founded as an academy for the sons and daughters of farmers and mechanics—the first institution of the kind in America. This transition is one of the most striking phenomena in the history of education. At first the Institute merely offered to students who had received a classical education an opportunity for special study. Before long, however, Eaton arrived at a clearer idea of its dependence upon the arts colleges. Its function, he pointed out, was entirely different from theirs. In no sense could it be called a rival; for it relied upon them to fashion its students as gentlemen and to

provide them with the knowledge of literature and the polish of manner essential to professional success. As early as 1827, the authorities announced that graduates of recognized colleges and of the United States Military Academy could complete the requirements for a degree in half the usual time. A little later Eaton added that the courses at the Institute were intended primarily for those who had completed their academic education; and, in 1832, he boldly proclaimed that it might "be considered the *common workshop* for all colleges, academies, and other literary and scientific seminaries of learning." Even to clergymen, lawyers, and physicians it professed to offer opportunities that were not provided elsewhere. What Eaton visualized was a graduate school not unlike that proposed fifty years afterward by President Gilman at Johns Hopkins.

Not only did he visualize such a school, but he made Rensselaer one in fact as well as in name. For three decades, therefore, Troy was to the aspiring youth of America

what Germany became in the succeeding period. At times nearly half of those enrolled were college graduates. In the early years it drew constantly upon older institutions such as Amherst, Bowdoin, Columbia, Dartmouth, Harvard, Pennsylvania, Princeton, Yale, Union, Wesleyan, and Williams. From some, like Yale, where there were teachers interested in the sciences, there was a considerable stream of students. As a result, many of those whose names are mentioned in this volume—men like Ebenezer Emmons ('26), from Williams, and James Curtis Booth ('31), from Pennsylvania—came to the Institute, at which they sometimes remained for several years, prepared to make the most of its facilities. Moreover, after the Civil War, it attracted men from the newer colleges as well as from the technical institutions which had sprung up in the East. In all it served in this way nearly one hundred centres of higher learning. Since Rensselaer was thus the first graduate school of America, and since its authorities stressed persistently

the need of research, it was natural that its alumni—often college graduates—should have been the first to adventure into the great universities of Europe. In view of this fact, the reorganization of the graduate courses which has just been completed links the present celebration with developments in the last century that now appear highly significant.

In its influence upon the education of women, upon instruction in agriculture, upon the development of the college curriculum, and even upon the character of the graduate school, the Institute soon surrendered its position of leadership. In the pure sciences, however, it remained supreme for thirty years; and for more than twice that time it maintained a similar supremacy in the applied sciences. Though it now shares its rank with several institutions of high merit, their existence is a tribute to its success. In the interpretation of the forces of nature and their adaptation to the exigencies of civilization, it has been the most vital force in the

history of the continent. In 1850 the majority of the naturalists and engineers who were teachers or practitioners in the United States were alumni of the Institute. Without them to man the new departments and to direct the construction and operation of railroads and factories, the Industrial Revolution would have been postponed for twenty-five years. Those aspects of life which to-day seem most characteristic of America can therefore be traced in many instances to the foundation of Stephen Van Rensselaer.

CHAPTER II

CURRICULA AND TRADITIONS

One of the most fascinating studies in the realm of scholarship is the evolution of the curricula at the Institute. Since their development is inextricably associated with the directorships of Amos Eaton and Benjamin Franklin Greene ('42), it may well be considered from their points of view.

In the last chapter, I suggested a few of the ideals which Eaton attempted to realize in Troy. Though his interest in the education of women is not reflected in the courses which he established at Rensselaer, his attitude toward scientific, agricultural, and industrial training is indicated in the early bulletins. In them it is easy to trace his conception of the college and the graduate school.

Before turning to the first curriculum leading to a degree—that of bachelor of arts—it seems advisable to describe the character of

the preparation advocated by the senior professor. Though the requirements emphasizing the necessity of mathematics and rhetoric and the usefulness of history, English literature, and Latin can be found elsewhere, the subjects offered by the Preparation Branch, announced in 1826, are excellent criteria. Those mentioned as occurring in the forenoon in one of its five divisions are practical mathematics, botany, geography, history, moral philosophy, logic, rhetoric, etymology (including derivations from Greek, Latin, and French), government, law, and parliamentary rules. As in the advanced course, instruction was carried on by means of "extemporaneous dissertations" from "concise written memoranda." The afternoons were devoted to "scholastic amusements" consisting, in the summer, of field work, and, in the winter, of laboratory practice. These "amusements" included botany, entomology, mineralogy, physics, chemistry, and the rudiments of agriculture and civil, electrical, and mechanical engineering. In general, therefore, the

curriculum of the Preparation Branch was an elementary duplicate of that leading to a degree.

A review of the subjects required for graduation shows that Eaton regarded the sciences as the core of the "Rensselaerian Plan." Around them he grouped whatever studies he felt necessary to complete the kind of education which he believed to be best adapted to the needs of modern life. As he came to understand these needs more fully, he altered materially the content of the courses offered by the Institute. As a result, the degree of bachelor of arts was superseded, in 1835, by one in natural science. By this time the requirements in botany, zoology, physiology, geology, mineralogy, mathematics, physics, and chemistry had been moulded into an organic unit which was undoubtedly superior in many respects to any other curriculum of the day. It was this superiority which made possible the epoch-making achievements of the alumni enumerated in the next chapter.

Many of these achievements were con-

nected with the development of agriculture. Since I have already referred to the character of the courses in this field, it is possible to turn to those which were connected with industry, and which therefore anticipated the present curricula in engineering not only at Rensselaer but also at all other institutions in America. As President Ricketts has pointed out in his *History*, these courses grew up gradually within a decade. In 1825, surveying and the elements of hydrostatics and hydrodynamics were listed among the subjects taught. A year later "general engineering" appeared, and, in 1828, "civil engineering." In 1835, when the degree of civil engineer was introduced, four young men presented themselves for examination. They were the first in any English-speaking country to receive a diploma in engineering.

By 1835, then, the Institute had developed a closely integrated course in technology which was distinctly professional in character. The alternate course in natural science, which had also become a well-rounded unit, repre-

sented Eaton's contribution to the curriculum of the American college. The subjects listed in the last chapter indicate the manner in which he attempted to relate students to their physical and social environment. Notable as was the advance made by the Institute in this connection, its emphasis upon the value of graduate study was even more striking. During the first twenty-five years of its history, the requirements for a bachelor's degree were crowded into a single year. Though this fact may seem to contradict what I have said regarding the wide and profound influence which it exerted throughout the United States, it should not be forgotten that the Preparation Branch laid an admirable foundation for mature scholarship and that many students who had not enjoyed its advantages were already college graduates. Since fourteen was the age set as advisable for entrance to this branch, with its various divisions; since twenty was the average age of matriculation, and since the examiners included such men as Chester Dewey and

Joseph Henry, the standard must have been reasonably high. Moreover, regarding the importance of research the authorities evidently held advanced views; for graduates —even if they did not proceed to a master's degree—were expected to communicate at least once in three years the results of their investigations and discoveries. The establishment of such a tradition was not the least of the services which Eaton rendered to his generation.

More than any other educator of his day, he stressed the importance of research. In fact, the whole routine of the Institute tended to develop initiative. The emphasis upon skill in manipulation, accuracy in observation, and efficiency in reporting results bore many rich and varied fruits. Even in the Preparation Branch students were thrown largely upon their own resources in that they were expected to perform many of the exercises "with apparatus made with their own hands." Since candidates for a degree were required to complete over sixteen hundred

experiments, and since theory was almost invariably based upon generalizations drawn from practice, most of the early graduates acquired a familiarity with scientific methods which it is not difficult to trace in their work. Moreover, since Eaton's primary aim was the popularization of knowledge, the authorities threw the burden of instruction largely upon the students themselves; and it was this system of daily lectures followed by informal discussions of their field studies or laboratory investigations which led so many of the alumni into public affairs.

In rounding out his scheme, which was characterized, as I have intimated, by due emphasis upon social and moral values, Eaton did not overlook the necessity of physical development. It must be confessed, however, that to the average undergraduate his ideas would now appear somewhat antediluvian. It must be confessed, also, that even from the point of view of physical education they were not particularly advanced. In fact, toward any provision for

"sport" he was persistently hostile. "Corporal exercise," he admitted, was "not only necessary for the health of students but for qualifying them for the business of life." On the other hand, "such exercises as running, jumping, climbing, scuffling, and the like are calculated to detract from that dignity of deportment which becomes a man of science." "In lieu of mischievous tricks, degrading contortions, called gymnastics, and profane language," he proposed the kind of "amusements" on the "school farms" or in the "school shops" which I have already described. In view of the weary hours now spent in every laboratory, these "amusements" must seem to many an ironical travesty of the term. Nevertheless, to Eaton they offered an opportunity for symmetrical development unhampered by the attractions suited only to the "parasites of Europe," which unfitted students "for either literary or scientific pursuits." Though such an attitude will doubtless seem amusing to the successors of the "free-born Americans" who have been

"corrupted" by the customs of the Old World, there are probably a few benighted educators who, even to-day, will sympathize in secret with the antiquated ideas of the republican professor."

By 1850, however, these ideas seemed old-fashioned even at Rensselaer; for the report of Greene, who had become director in 1847, anticipated, in a striking way, the modern point of view regarding physical education. A paragraph will give some idea at least of the boldness and originality of his proposals:

"Finally, it may be said that, although the methods of the Institute afford considerable opportunity for physical exercise in connection with the various field operations . . . still this incidental advantage is far from being sufficient to take the place of a course of systematic gymnastics as a means of rational physical culture. There is nothing more needed in these days of bodily insufficiency. . . . Even where gymnastics constitutes a part of the programme of educational courses—as it does in some of our schools for boys and

girls—it embraces little else in most cases than a room or yard, provided with a few of the commoner forms of apparatus, to be used *ad libitum* by the pupils. . . . This, even, is worth something; and we would not wish to estimate it below its just value. But gymnastic training, worthily so called, is a much more serious matter; for it implies an array of means for the complete and harmonious development of the whole muscular system—of the entire physical man; results which require a systematic disciplinary drill, under competent direction, of several years' duration, regularly filling up certain hours of each week set apart for this kind of culture. The resources gained by such a system of culture are not alone of a physical kind; they are largely intellectual and moral. Presence of mind, consciousness of physical capacity, power of command, and promptness of action in moments of critical and trying circumstances as well as on ordinary occasions are among the mental gains. While desirable for all persons—men and *women*—such a train-

ing is especially called for in the education of professional technists, who, besides needing the physical powers and mental control conferred by such culture for the most efficient conduct of professional duties as well as for self-preservation in times of personal danger, are sometimes suddenly confronted by an array of circumstances where the safety of the lives and limbs of hundreds of workmen and others may be, in a measure, dependent upon their possession of just such resources as those here described. Much might be said in respect to the favorable influence upon the general health of such culture; and very many reasons might be urged why it should form a parallel and contemporaneous system in all intellectual education of the young of both sexes. . . ."

This passage is indicative of the mastery with which Greene, who discussed such subjects as deanships and dormitories in the same enlightened manner, grappled with the complexities of reorganization at the Institute.

In preparation for the task he analyzed the curricula of the leading institutions of France and Germany, from which he drew certain conclusions, which appear in his report. To-day, after the lapse of nearly seventy-five years, his recommendations seem as sound as when they were first presented. Though they have been modified in detail through invention and research, their implications have remained unchallenged. For this reason a review of Greene's proposals, which included the whole range of elementary and collegiate education, is of more than local interest.

Since he aimed at a type of training which should be closely integrated, he systematized, in the first place, the courses in the Preparation Branch. In this school, as reorganized, an "elementary class," extending over a year, was followed by a series of "general classes," three years in duration, which were devoted to the languages—Latin, Greek, French, German, and English—to mathematics, to descriptive and experimental science, and to

the graphic, vocal, and gymnastic "arts." Greene's greatest contribution to the theory of secondary education, however, is to be found in the curriculum of the "special class," covering a year, in which the nature of the instruction in the mathematical and classical sections was adapted to the character of the college which the student proposed to enter. This differentiation, which is reflected to-day in the curricula of every secondary school, is one of the numerous instances of the manner in which the Institute anticipated changes with which its name is never associated.

Greene's chief claim to distinction, however, lies in his proposals for a polytechnic institute as comprehensive as its title. Though Eaton had insisted that most colleges attempted to teach so many subjects that they could teach none of them well, and that Rensselaer should limit its activities primarily to the sciences, progress in them had been so rapid that Greene believed that it was again time to narrow its field. While pointing out that a school of forestry and a

school of agriculture might well be considered, he eliminated them because "as a matter of expediency" they would probably have to be administered independently. While suggesting, also, that a school of commerce "with elevated aims" ought to be included in a polytechnic organization, he nevertheless restricted his recommendations to "matters immediately cognate to architecture and engineering." Because of its historic significance, his treatment of these "matters" is worthy of note.

As I have already intimated, Greene's point of view was remarkably catholic. While emphasizing those "matters" which seemed "immediately cognate" to his purpose, he did not overlook those which are more remote but no less essential. In the "general school," as he styled it, which dealt with such subjects as languages—English, French, and German—philosophy, botany, zoology, geology, mineralogy, physics, chemistry, mathematics, and the geodetic, graphic, plastic, and gymnastic "arts," his aim was

to offer a system of general *disciplinary culture*—scientific, literary, philosophic, artistic —prior to entrance upon a "study of any form of applied science or art." In the "technical schools," leading to professional preparation, courses were grouped under "general studies" and "special studies," according as they were common to the needs of all groups of students or were applicable to those of one group only. Within the boundaries of the time limit—three years—which he had set, Greene attempted, therefore, to provide a complete liberal and professional education.

In his report, written practically twenty years before Huxley's famous essay, he emphasized the cultural value of the disciplines which he advocated. While expressing his appreciation of the ideals which had illuminated the universities of Europe and his readiness to accept in their own place those which had been borrowed by the colleges of America, he nevertheless insisted upon the validity of his own point of view. Not the least of the misconceptions regarding the pur-

pose of the Institute, according to him, was the prevalent idea that its object was distinctly vocational and that it was unable to provide its students "with that completeness of scholarly culture which is comprehended in the idea of a liberal education." Actually, however, he added, its courses were neither "partial" nor "one-sided" but "*adapted to the complete realization of true educational culture*," ministering to all the "powers of perception, of thought, of feeling, of expression, of action" and aiding the undergraduate to meet "the demands and circumstances of the age in which he lives." Such was the wise and tolerant definition with which Greene began his plan of reorganization.

Though it was subject to attack from those who misunderstood his attitude toward the classics, it was also subject to attack by those who would sink "all learning to the level of the merest empiricism." Regarding their onslaught he remarked:

"The question may be raised as to the utility of such studies as rhetoric, philosophy,

etc., to the architect, engineer, and other technists. It is a natural question, and one not unfrequently asked in these days, when the element of *time* which is spent in connection with education is estimated at so high a value. Experience has shown conclusively enough to all observers that in a course so largely—in its very necessities—*material* as that which obtains in a polytechnic institution there should be introduced compensating or balancing elements. And what studies so suitable as those which cause us to turn from the observation of *things* without to the contemplation of the wonderful phenomena and resources within the human mind! Apart from all consideration of the practical advantages which accrue even to the technist—and they are not only manifold in fact but *ought to be obviously so* to all intelligent and discriminating observers—from this class of studies, we repeat that, viewed as a mere *equipoise* to the study of the mathematical, physical, and technical sciences, we believe they should find a prom-

inent place in the educational system of every polytechnic institution."

As I have explained, Greene had envisaged an institution which would deal with all "matters immediately cognate to architecture and engineering." Within the limits of these terms, he included not only "schools" of "civil architecture," "civil engineering," and "mining engineering" but also "schools" of "pure art" and "ornamental art." Because of lack of funds, however, only the "school of civil engineering," offering the degrees of civil engineer and topographical engineer, was actually organized during his directorship. Though he was unable to introduce many of his recommendations, he charted the trail which others have followed. With the exception of local divergencies in content and method, engineering education to-day may be interpreted almost entirely in terms of his report. So sound were his conclusions that Dr. Charles Ribourg Mann's study for the Carnegie Foundation consists of little more than a reinforcement of his

views as modified by conditions at the time when it was made.

In the leadership of both Eaton and Greene, therefore, Rensselaer was peculiarly fortunate. Since their administrations, also, it has found others to further their ideals. Seven years after Greene's resignation, the course leading to the degree of topographical engineer was changed to one leading to the degree of mining engineer. In 1862, when the "special class" leading to the curriculum of three years in civil engineering became the first year of the new four-year course, which has remained the norm in the United States and Canada, a curriculum in mechanical engineering was added. Both of these courses, which, with that in natural science, were abolished in 1871, represented departures which were afterward elaborated in other institutions. Not until 1907 were courses in mechanical and electrical engineering placed upon a permanent footing, and not until 1913 was a similar course in chemical engineering differentiated from that in science. In keep-

ing with the traditions of the Institute, the curriculum in civil engineering had been distinctly general in character, and the new curricula were moulded in similar form. Many other improvements advocated by Greene have also been introduced. Though Rensselaer to-day offers no course in commerce such as he proposed, it has not been oblivious to the growing correlation of science and industry. Nevertheless, development has proceeded on other lines. In recent years the chief contribution of the president and the trustees has been to the life of the Institute as a whole. To make possible the most thorough instruction within the limits of the eight semesters leading to a degree has been their principal concern. To this end they have bent all their energies to provide buildings, laboratories, and professorships as they have been needed. Though the proper utilization of the equipment which they have provided has depended upon the members of an able faculty, some of whom have been distinguished in their special subjects, prog-

ress has depended no less upon the efforts of the alumni. While they have rallied generously to the support of their *alma mater*, their most notable services—those on which its reputation finally rests—have been their achievements in the fields which they have made their own.

CHAPTER III

THE NATURAL SCIENCES

Not long ago an eminent scholar referred to the development of the Institute as an illustration of the utilitarianism of American life. A college of pure science, devoted primarily to research, it has become, according to him, a school of practical arts. To those who are unfamiliar with the conditions which existed when it was founded, this explanation of its early prestige in botany and zoology, in physics and chemistry, and in geology and mineralogy may seem entirely plausible. As a matter of fact, however, its ideals have never changed. If the achievements of its graduates in the biological and physical sciences are examined in the light of their origins, it will be found that in most cases they sprang from a desire to subdue the forces of nature to the needs of men. It was the fact that it was necessary to understand

these forces before they could be effectively utilized which made Rensselaer for three decades the scientific centre of the United States and that, with Harvard, McGill, and Yale, made it for six decades one of the citadels of research in America. Moreover, as Benjamin Silliman and others have testified, it was the only popular exponent of the New Learning. As a result, it exerted upon the state universities, when they were established, an influence that was not paralleled by that of any other institution. In the West at least the aspirations of its founders have been justified by their fruits.

Since Amos Eaton was a naturalist of the old school, almost a "philosopher," in the Chaucerian sense, he ranged over all the subjects which I have mentioned in the last paragraph; and in every field he fired the imagination of students who outreached him in knowledge and attainment. This statement is true of several of the biological sciences which to-day seem remote from the curricula of the Institute. By 1828, as I have

intimated, Eaton had published treatises, manuals, exercises, and dictionaries dealing with various aspects of botany. The eighth edition of his *North American Botany*, issued in 1820, contains descriptions of 5,267 species. Under the circumstances, it is not surprising that many of the early graduates followed in his steps. Some of them paralleled his intellectual excursions with remarkable fidelity. James Hall ('32), of whose work at the University of Iowa I shall speak later, printed his *Catalogue of Plants Growing Without Cultivation in the Vicinity of Troy, N. Y.*, in 1832, before he began his career as a geologist. John Leonard Riddell ('29), professor of botany at Cincinnati, and, during the first thirty years of its history, professor of chemistry in the University of Louisiana, issued his *Synopsis of the Flora of the Western States* (1835), before becoming melter and refiner of the mint at New Orleans and inventor of the binocular microscope and magnifying-glass. Douglas Houghton ('29), a classmate, who organized the Michigan

State Geological Survey after the commonwealth had been admitted to the Union, acted as botanist on the first expedition to the source of the Mississippi. His able report on the flora of the Northwest can be traced today in the Houghton Herbarium at the University of Michigan. When he undertook the Survey in 1837, he naturally surrounded himself with Rensselaer men, one of whom, Abram Sager ('31), now remembered by the Sager Herbarium, became chief of the botanical and zoological divisions. Sager, who, like several other graduates of the Institute before 1850, luxuriated in every field from paleontology to obstetrics, laid the foundations of the departments of botany and zoology in the University. It is true that Asa Gray, who had also been inspired by Eaton, had been connected with it for a few months; but his connection was merely nominal. As in half a dozen other universities in the West, the pathfinders had been students in Troy.

Though Eaton's *Zoological Syllabus and*

Note Book, published in 1822, emphasizes his interest in the biological sciences, the character of this interest is revealed more accurately by his *Geological and Agricultural Survey of the County of Albany, N. Y.* (1820) and his *Geological and Agricultural Survey of the District Adjoining the Erie Canal* (1824). These volumes, reports of investigations which he had made through the patronage of Stephen Van Rensselaer, illustrate the practical side of his genius. They are interesting memorials of the first attempts to adapt the results of research to the needs of agriculture. When the history of education in the United States is finally written, it will be found, I think, that the Institute was a powerful factor in shaping the agents which have ministered to its necessities.

In 1843, Ebenezer Emmons ('26), who lectured—as usual at the time—on chemistry, geology, and mineralogy in Albany, Rensselaer, and Williams, and who, in 1836, became head of one of the four divisions of the New York State Geological Survey, was

appointed chief of the agricultural section. In the next decade he issued four reports, the first dealing with the soils and rocks of the district; the second, with the grains and vegetables; the third, with the fruits; and the fourth, with the noxious organisms. From his monographs, which were illustrated—for the first time—by figures and plates, have sprung the bulletins of the United States Department of Agriculture. Even in the case of the bureaus associated with it, the Institute was also a leader. In 1830, Eaton organized the first of his famous "expeditions" for the collection of plants, insects, rocks, and fossils. On this excursion from New York to Lake Erie—an excursion which marked the beginning of serious field work in America—he was accompanied not only by Houghton, Emmons, and Fay Edgerton ('28), whom I shall mention again, but also by Asa Fitch, Jr. ('27), who specialized in entomology. Henceforth Fitch devoted himself to this study. In 1848, he was engaged by the New York State Agricultural Society

to make a survey of Washington County, the results being incorporated in the *Transactions* of 1848–49. Previous to this time, however, he had contributed numerous articles to the *American Quarterly Journal of Agriculture and Science*, which had been projected by Emmons. Among the subjects which he treated were the wheat-midge, the Hessian fly, and the currant-worm. At last, in 1851, after he had collected and classified a large number of specimens for the State Museum, he prepared a catalogue of homoptera which is still valued by specialists. In view of his reputation, it was natural that when the Legislature in 1854 appropriated funds for the employment of an official entomologist—the first in America—he should have been selected for the position. During the next thirteen years, a period in which he issued a series of annual reports, he made secure his place as the "father of economic entomology." Although Van Rensselaer's aspirations regarding agriculture have gradually been obscured by the claims of industry, they

have thus been realized in the activities of the national bureaus which are the legitimate descendants of the small organizations established by Emmons and Fitch.

The part played by the graduates of the Institute in the first colleges of agriculture was no less important. West of the Alleghany Mountains, they found people peculiarly responsive to the theories of education which they had brought from Troy. The Morrill Act of 1862, foreshadowing the type of institution which Eaton had envisaged, offered them an opportunity of which they took full advantage. When the University of California was opened, in 1869, Ezra Slocum Carr ('38), who had held the chair of chemistry and natural history and of chemistry as applied to agriculture in the University of Wisconsin, was called upon to become first professor of chemistry as applied to agriculture or, as he was more often called, merely "professor of agriculture." The career of Hall, however, offers an even better illustra-

tion of the ideas which Rensselaer men carried beyond the Mississippi. In connection with the Iowa State Geological Survey, he became first professor and head of the department of natural history in the university, which he helped to establish. Though he apparently never delivered any lectures, he insisted not only on the importance of botany, zoology, geology, and mineralogy from an academic point of view but also upon the necessity of considering their applications to agriculture. According to President MacBride, he anticipated the progress of the commonwealth in rural education. In similar paths the alumni were also trail-breakers; for George Hamill Cook ('39)—like Hall, an adventurer in many fields and a geologist of note—became director of the first experiment station in New Jersey, one of the earliest on the contiment. In the bureaus, colleges, and laboratories devoted to agriculture the ideals of 1824 still linger, although the students of the Institute no longer "amuse" themselves on pleasant afternoons by studying vegeta-

bles or pruning trees on "well cultivated farms" in the neighborhood.

The interrelation of the natural sciences before 1875 is especially noticeable in the case of those which belong to the second group. In the early part of the nineteenth century, "natural science" and "experimental philosophy" went hand in hand. It is difficult to divorce them. In fact, three graduates of the Institute, the most distinguished of whom was John Pemberton, Jr. ('60), held professorial posts under this double-headed title at the United States Naval Academy. By 1850, however, physics was able to stand alone. Since most of the alumni, however, were teachers and not investigators, they have left little trace of their labors except in the institutions which they served, although George Washington Plympton ('47) must be credited with many advances at both the Brooklyn Polytechnic Institute and the Cooper Institute. The one alumnus who left a permanent impress upon his generation was Henry Augustus Rowland ('70). Since

his father, grandfather, and great-grandfather had been clergymen, graduates of Yale, he was naturally sent to Newark and Andover to prepare for college. So great was his dislike of Latin and Greek, however, and so absolute was his devotion to mathematics and mechanics, that he was eventually allowed to enter Rensselaer, where, in spite of the meagreness of its equipment, he immediately felt at home. Except for a couple of terms at Yale, he spent the next five years in Troy. Graduated as a civil engineer, he passed a year in the field and another as instructor at Wooster, Ohio. In 1872 he returned to the Institute. During the next three years, in which his salary as assistant professor of physics was decreased—for such was the agreement—as the appropriations for apparatus were increased, he began the investigation of magnetic permeability which established his reputation in Europe. As a result, he was appointed first professor of physics in Johns Hopkins University; and, in 1876, after a trip across the Atlantic to purchase supplies, he set up

his "shop" in the two houses which he was to make famous. Born at a fortunate moment and called to a chair carrying with it opportunities for research unrivalled in America, he influenced the study and teaching of physics in a manner which is not likely to be paralleled in the future.

Because of the far-reaching results of his experiments, some comment on them is imperative. As I suggested in the last paragraph, he began in Troy those dealing with the maximum magnetization of iron, nickel, and steel which led to new and revolutionary conceptions of magnetic phenomena. As a result, the laboratories of the Institute are associated with the discovery and announcement of the principle of the magnetic circuit. In addition to the studies leading to the establishment of this analogue of Ohm's law, Rowland apparently laid at Rensselaer the foundations for his researches on the magnetic effect of electrostatic charges in motion. At any rate, he proposed to von Helmholtz certain procedures which he had been unable

to employ because of lack of apparatus. Of his work at Johns Hopkins little need be said. While there he completed his investigations relating to the mechanical equivalent of heat. Though less original and less daring than those which marked his first professorship, they have been no less useful. At Johns Hopkins, also, he conducted his experiments on magnetic convection. His most epoch-making contributions, however, were those connected with the development of spectroscopy, a field in which he made himself supreme. In addition, however, he devoted his energies to the determination of electrical units of measurement, a subject to which he had been attracted while at the Institute. As president of the Congress at Philadelphia, in 1884, and the International Chamber at Chicago, in 1893, he aided materially in the evaluation of the ohm, the ampere, and the volt. Though many of his labors were reflected in the advancement of electrical engineering, Rowland seemed to the public at large to be far removed from practical affairs.

Tall and ascetic in appearance, the founder and first president of the American Physical Society, with an intense interest in literature and a passionate devotion to music, he is still regarded primarily as an academician. Nevertheless, though he was a scholar, he was also a mechanician. His accuracy in observation and precision in thought were matched by his inventiveness and mechanical skill, without which his gratings could not have been manufactured. There can be little doubt that, if he had desired, he could have been a great engineer. As it was, he was often consulted on matters of importance. Moreover, during the latter part of his career, he showed by his studies of alternating currents and telegraphic systems that he had never lost his early interest in the applications of science. In all, there is no more significant figure in the history of physics in the United States.

Though there is no such outstanding name as Rowland's among the graduates of the Institute who devoted themselves to chemis-

try before 1875, their contributions to the New Learning were highly significant. During the second and third quarters of the nineteenth century, the subject was generally associated with geology and mineralogy; and for that reason it might well be considered with them. By the end of this period, however, it had established its claim to independence. The story of its evolution, as it can be traced in the careers of the alumni who aided in its advancement, is full of interest. As with botany and zoology, Eaton's name again emerges. In 1821 he had published his *Chemical Note Book* and in 1822 his *Chemical Instructor*. In the list of subjects which he professed in 1824, chemistry stands first. Moreover, in the early bulletins, attention is continually directed to its importance in the world of affairs. In one of these pamphlets, published before either the Lawrence Scientific School or the Sheffield Scientific School had been organized, the preface consists of little more than an extended quotation from one of Liebig's essays. Under these

circumstances—especially as Eaton had given, before 1828, thirty courses, each containing at least six hundred experiments—it is not surprising that the foundations of the departments of chemistry in about twenty institutions of high rank were laid by graduates of the Institute.

In keeping with its traditions, most of them were attracted by its applications to agriculture or industry, although, in some instances, their professorships did not relate to either. Houghton, for example, was the first professor of the old triumvirate—geology, mineralogy, and chemistry—in the University of Michigan. Carr, as I have indicated, introduced the subject in the University of Wisconsin. After eleven years at Madison, where he had also been professor of chemistry as applied to agriculture, he accepted a similar position in the University of California. In the application of chemistry to industry the contributions of the alumni have naturally been even greater. In the early days of the nineteenth century, two of

them stood out with considerable distinctness—James Curtis Booth ('31) and Eben Norton Horsford ('38), whose careers were similar in many respects.

After receiving his bachelor's degree from Pennsylvania, Booth, who had little patience with the theoretical demonstrations of his *alma mater*, entered Rensselaer. More determined than ever to carry out his plan of making the laboratory "a miniature factory" and the factory "a mammoth laboratory" he spent nine months in Hesse-Cassel and as many more in Berlin and Vienna. Returning to America as the first student who had sat under the masters of Germany, he organized in Philadelphia a laboratory for analysis, research, and instruction. Moreover, in addition to his duties as head of this famous institution, the first of its kind in America, he served as professor of chemistry applied to the arts in the Franklin Institute and later in the University of Pennsylvania. In the meantime, however, he had turned aside to geology and mineralogy. As a result of his

studies of nickel, which he introduced into the coinage of the United States, of cobalt, of gold, and of silver, he was appointed melter and refiner of the mint at Philadelphia. As director, he designed its furnaces, which he improved from decade to decade, and developed many original procedures. All his work, however, was not so directly utilitarian; for in both organic and inorganic chemistry he undertook many researches that were distinctly academic. One of the first presidents of the American Chemical Society, he wrote numerous monographs as well as most of the chapters in his epoch-making *Encyclopædia of Chemistry, Practical and Theoretical* (1845–50). It is no exaggeration to refer to him as the greatest chemist of his day.

Almost parallel with his career was that of Horsford. Interested likewise in geology, the latter served under Hall and Emmons. Finally, after a couple of years under Liebig, he was invited to Harvard, where, as Rumford professor of the application of science

to the useful arts, he induced Abbott Lawrence to establish a school devoted to analytical and practical chemistry. In this, the Lawrence Scientific School, he conducted the first laboratory courses of any importance given in Cambridge. During most of his tenure, it is interesting to note, President Eliot was assistant professor, resigning, when Horsford became head of the Rumford Chemical Works, to establish the department of chemistry in the Massachusetts Institute of Technology. Even after his acceptance of this position, however, Horsford maintained his interest in education, assisting materially in the development of Wellesley College. Not only did he endow its libraries and laboratories and provide the material and apparatus necessary for instruction in the physical and biological sciences, but he also introduced a system of pensions for the president and heads of departments as well as an arrangement for sabbatical years in Europe. In his services at Harvard and at Wellesley, where he stipulated that the administrative officers

should be women, he reflected two of the cherished ideals of the Institute. In another respect, also, he reflected one of the interesting features of life in Troy; for, in addition to numerous studies in his chosen field, he made at least one important contribution to American philology. In the history of chemistry in the United States, his name deserves an honorable place.

Great as have been the services of the graduates in botany, zoology, physics, and chemistry, as well as in pure mathematics, a field in which a dozen alumni like Henry Pomeroy ('41), founder of the department in Washington University, and Joseph Fox ('61), founder of that in Cooper Institute, were recognized leaders, it is doubtful whether they have equalled those in geology and mineralogy. As in the other sciences, the original stimulus came from Eaton. Of his surveys in New York I have already spoken. In addition to his reports upon these surveys, he was the author of four treatises upon geology. These monographs, one of which contains the

first illustrations of organic remains, have been supplemented by nearly five hundred studies written by alumni. Through their contributions it is possible to trace the progress of geology and mineralogy in the United States during the nineteenth century. Indeed, of eleven "events and forces" which, according to Professor Herman LeRoy Fairchild,[1] influenced development before 1848, five were connected with the Institute. In the East, the South, and the West, its influence was a compelling force in the local bureaus and universities.

During the first part of the period, the New York State Geological Survey occupied a dominant position. At first, in 1836, it was divided into four sections, one of which was entrusted to Emmons, who discovered the Taconic (Cambrian) system, and who, in Troy, Williamstown, and Albany, labored zealously in school and college for the advancement of his favorite study. The im-

[1] "The Development of Geologic Science." In *Scientific Monthly*, July, 1924. XIX. 77–101.

portance of these labors is emphasized by the fact that his old home in the Capitol City—the house in which the Association of American Geologists was projected—now bears a tablet erected by the authority of its lineal descendant—the American Association for the Advancement of Science. A year after Emmons began his work, Booth, in Pennsylvania, proved that the mountains which fill the middle belt of the state arose from two separate formations. On the announcement of this discovery, which was of far-reaching significance, he was appointed chief of the newly organized Delaware State Geological Survey. Moreover, after the failure of the New Jersey Geological Survey, Cook, who had been assistant, and who later accepted the responsibility of administration, made many notable advances in methods of mapping. Though it would be pleasant to follow the alumni elsewhere in the East, their services in New York demand special attention. Of the graduates associated with the State Survey, Hall was undoubtedly the

most eminent. Under Emmons, he was assistant in the Second Division. In 1836, he was appointed geologist for the Fourth District; in 1843, paleontologist of New York; and, in 1866, director of the State Museum. For nearly sixty-five years—during which time he served as first president of the American Geological Society and as one of the first presidents of the American Association for the Advancement of Science—he was immersed in public affairs. For many years, also, he was professor of geology and mineralogy in the Institute. With him, or under him, served many graduates such as Horsford, whom he induced to enter Rensselaer; Carr, with whom he was afterward associated in Wisconsin, and James Henry Salisbury ('46), principal of the chemical department at Albany and president of the American Institute of Micrology. His reports—filled with echoes of controversies long since forgotten except by specialists—illuminate every phase in the development of his chosen field in the Eastern States. He has

been called the "founder of American stratigraphy," the "father of invertebrate paleontology," the "master" without whose discoveries, in the words of James Dwight Dana, "the geological history of the North American Continent could not have been written." In recognition of his unique place in the development of the science, the Association of American State Geologists in 1916 placed a tablet on the building which, for nearly fifty years, he used as his office and laboratory.

During this period, the graduates of the Institute were not idle in the South. Though Hall refused an offer of the professorship of geology and agricultural chemistry in the University of Alabama, with the promise of a survey if interest could be aroused, and also a position in the Missouri State Geological Survey, he lent material aid, through recommendation or advice, in both Mississippi and Texas. Other Rensselaer men, however, were personally active. Emmons, in North Carolina, who was engulfed in the maelstrom of the Civil War, was one of the most distinguished.

Michael Caleb Briggs ('35), who had been associated with the Ohio State Geological Survey, joined Rogers in Virginia. In 1847, his classmate Michael Tuomey ('35) became state geologist of South Carolina; in 1847, professor of geology, mineralogy, and agricultural chemistry in the University of Alabama; and, in the following year, state geologist. His reports are among the earliest and the most comprehensive published in the South.

In the West the story is much the same. In 1837, Houghton, aided by Sager, had undertaken the Michigan State Geological Survey. Next year he was appointed professor of geology, mineralogy, and chemistry at Ann Arbor. Like Houghton, Hall, who was summoned to organize the Iowa State Geological Survey in 1855, also ranked as first professor of geology in the university. As early as 1841, he had led an expedition into the Middle West to extend the geological boundaries of New York. On this trip he had explored not only Michigan but also Illinois,

Indiana, Iowa, Missouri, Ohio, and Wisconsin. His thoughts were thus turned westward at an early date. Meanwhile, Carr, who had been one of his assistants in New York, and who, as I have noted, had been called to a professorship in the University of Wisconsin, had become one of the commissioners of the Geological Survey. Through him, probably, Hall became commissioner and, later, superintendent. Of Hall's influence in other states and provinces—for his services were international—Dr. John Mason Clarke—like Hall, director of the New York State Museum and long professor of geology at the Institute—has touched in his admirable biography,[1] through whose pages move the alumni who made the valley of the Hudson, for no inconsiderable period, a rallying point for the scholars of America.

In summarizing even briefly in this way the contributions of the alumni to the natural sciences, those who taught in the secondary

[1] *James Hall of Albany, Geologist and Paleontologist*, 1811–1898. Albany, 1921.

schools cannot properly be omitted. Far in advance of their fellows, many of them, like Fay Edgerton ('26), under whom James Dwight Dana studied in the Utica Museum, reflected in their lives the ideals of Stephen Van Rensselaer and Amos Eaton. If to their labors are added those of the graduates who, as surveyors-general from New York to California, charted the unbroken wilderness, the high phrases of the frayed and yellowed catalogues that appear quixotic at times in view of the poverty of the Institute and the slightness of its equipment, assume a new dignity and a new significance—the dignity and significance of a great tradition informing to-day in every state the spirit of those who have risen to be its heirs.

CHAPTER IV

THE LEARNED PROFESSIONS

The relation between the college and the professional school has long been a subject of controversy. Because of this fact, it is interesting to recall that the Institute was originally both. Indeed, Eaton insisted that it offered a sounder basis for vocational training than the older institutions of the East. And in the case of medicine, for instance, it is obvious that the background which it provided was unexcelled. In its insistence upon the natural sciences and their auxiliary studies—a discipline supplemented in most instances by a brief apprenticeship or a year at Castleton—it foreshadowed in a remarkable way the pre-medical courses of the present period. Any sketch of its graduates must therefore take into account those who became clergymen, lawyers, dentists, or physicians.

Strange as it may appear, most of those who were attracted by the church in the nineteenth century were graduated after the curricula had become highly technical. The manner in which they were turned aside from engineering would doubtless make a fascinating narrative if the materials for one had been preserved. As they have probably disappeared, speculation would be futile. It is a curious fact, however, that although the clergymen who were graduated from the Institute occasionally drifted into the easy emoluments of a city parish; that although one of them became a prolific writer on theological subjects; that although another became a distinguished professor of divinity, and that although another—Richard Edwards ('46), the heir to a famous name—became not only writer and professor but college president as well, most of them have been adventurers at heart—chaplains on the field of battle, missionaries in the Orient, or, like Aaron Ladner Lindsley ('42), who built the first American school in Alaska, muscular

Christians of a practical turn. If the task were worth the pains, it might not be impossible to trace in the romantic texture of their lives the influence of the "expeditions" to which they had been accustomed in their youth.

Even in the last two decades, a few graduates have entered the ministry. These instances, however, are exceptional. In law, however, the situation is entirely different. The alumni have always been attracted by the legal profession. In the first part of the Victorian Era, thirty of them were called to the bar. In most cases their abandonment of science or engineering was doubtless a matter of expedience. Though John Henry White ('40) distinguished himself as city attorney of New York, jurisprudence for its own sake has appealed to few. Nevertheless, some of the graduates have made honorable, if not great, names on the bench. Several have been judges of important courts; and one, Edwin Bryant Crocker ('33), chief justice of California at a formative period in

its development, left an indelible mark on the settlement of the West. With the record of the past that of the future is likely to coincide. Since law in an industrialized community can seldom be divorced from business, and since the curriculum of a technical school, if it is sufficiently liberal, can be made an admirable introduction to the world of affairs, there is reason to believe that the traditional academic preparation may be displaced, to some extent, by one that is more distinctly scientific. In recent years this shift has been apparent at Rensselaer.

Both the church and the law—the two oldest professions—were clearly differentiated in America by 1825. Dentistry and medicine, however, were still in a chaotic state. Standards were uncertain, and techniques were almost as numerous as the colleges which demonstrated them. Between dentistry and medicine, in fact, there was no line of demarcation. As both rest upon a scientific basis, it was natural that in the first years of its existence the Institute should

have attracted more than forty young men who became physicians. An illuminating commentary upon the status of their art before 1850 is the list of their contributions to the development of oral surgery. Many notable advances were due to their engineering skill. One of them, Amos Westcott ('35), first president of the New York State Dental Society, was the founder of the *American Journal of Dental Science*. An even more striking commentary upon conditions before 1850 is the fact that they moved easily from professorships in one field to those in another. Though I shall touch elsewhere on the career of Reed Brockway Bontecou ('42), who established the first army general hospital in the Civil War, and who became the chief historian of the period, the most important work done by the alumni has been in medical education. In Ann Arbor, Berkeley, Cleveland, Philadelphia, Madison, and New York, where they introduced the practical methods of instruction which they had learned in Troy, and which have since become universal,

they have left the impress of their personalities. In chemistry especially, the list of colleges in which they established departments devoted to analysis and diagnosis is a long and imposing one.

In illustration I might cite the achievements of Ezra Slocum Carr ('38) in the great professional schools of California, New York, Pennsylvania, and Wisconsin. A more typical figure, possibly, is Abram Sager ('31). Becoming interested in botany and zoology through the teaching of Amos Eaton, he extended his knowledge of these subjects while attending lectures in medicine and, in 1837, as I have shown, became chief of the corresponding departments in the Michigan State Geological Survey under the direction of another Rensselaer man, Douglas Houghton ('29), first professor of geology, mineralogy, and chemistry in the University of Michigan, which had just been established. From this time until his death, in 1877, his life was inseparably connected with that institution. During 1842–45, when the first

class was graduated, he was professor of botany and zoology. After 1848 he was professor of the theory and practice of medicine, professor of obstetrics and of diseases of women and children, and, finally, dean of the medical faculty. In addition to his other services, he laid the foundations of the botanical and geological collections, including those in the Sager Herbarium, as well as the craniological, neurological, and embryological collections in the Museum of Anatomy and Materia Medica. In its richness and variety his career illuminates a fascinating period in the development of American medicine and a forgotten page in the history of the Institute.

CHAPTER V

THE NEW HUMANITIES

Though Rensselaer, after the reorganization of 1832, became in name a "classical" and "experimental" school, the first department existed on paper only; and gradually the Institute surrendered its claim to recognition as a college of belles-lettres. Nevertheless, in spite of this fact, its curriculum remained remarkably broad. Since "composition" and "criticism" were required in 1852 during the three years, it is doubtful whether, in English at least, any institution offered more complete or more practical courses. In view of this fact, it is not strange that some of the graduates have been more devoted to the humanities than to the sciences.

In pure literature, as might be expected, their achievements have not been striking. Nevertheless, their contributions to the chief American and English periodicals of the

nineteenth century would make no inconsiderable collection. Of their more pretentious work, most is as romantic as their lives; for many of them were wanderers in far places. One, for example, is set down in the records of the Institute as a "smuggler on the Spanish Main." Another became a soldier of fortune in Southern Europe, a general, and a favorite of kings; another, still, the hero of numerous encounters with the Chinese pirates of the Pacific. From such a background sprang *The Nautch Girl* (1870), by Charles Thompson ('60), one of the lurid tales of the South Seas, to which the revival of Melville has recently directed attention. Of such romancers the most prolific was Henry Sedley ('48), author of *Dangerfield's Rest: A Romance* (1864), and *Marion Rooke; or, The Quest for Fortune* (1865), an old-fashioned "three-decker" now known only to bibliophiles. All these *lusus*, however, are, like most books of verse and criticism written by the alumni, literary curiosities over which it is impossible to linger.

In journalism, on the other hand, their careers cannot be dismissed so lightly. At first the number who have been attracted by the opportunities of the "fourth estate" may seem surprising. It should not be forgotten, however, that the early courses in composition and criticism, with their emphasis upon the collection and interpretation of material, offered an admirable training in the types of exposition most useful to reporters. As a result, there are few phases of journalism in which the graduates have not adventured. With its technical aspects I am not concerned. They alone would require considerable space. Elsewhere I have mentioned, in passing, the alumni who projected some of the earliest journals of agriculture, industry, dentistry, and medicine. In special fields as varied as theology and technology, they have also been publishers. Marshall Hubert Mallory ('65), for example, was long proprietor of the *Churchman*, the principal organ of the Episcopal Church; and to the firm of John Wiley & Sons, which has

touched all the sciences, the Institute has always been closely related. Of necessity, the careers of those who have devoted themselves to special subjects—of those, for instance, who have been editors of such periodicals as the *Engineering and Mining Journal* and the *Engineering News*—lie outside the limits of this chapter. On the other hand, those who served the masses through the newspapers of their day were often humanists in spirit. Of these, probably the most colorful was Edward Maxwell Grant ('60), gentleman-at-large, who became a war correspondent of the London *Daily News* at Belgrade and a staff reporter of the London *Daily Times* during the Russo-Turkish imbroglio. The great journalists, like John Cox Underwood ('62), lieutenant-governor of Kentucky, have naturally followed more conventional paths. Of the metropolitan papers of which they have been editors, the most notable are the Cincinnati *News Journal*, the Louisville *Post*, the New York *Evening Post*, and the New York *Times*. These titles are

sufficient to indicate the extent of the audience reached by the graduates of the Institute in the nineteenth century. If time served, it would be interesting to trace the influence which they evidently exerted upon the popular attitude toward the New Learning.

Since the littérateurs and the journalists who have been introduced in this chapter have been admitted by courtesy, it is necessary to turn to the scholars who belong by right. In the old sense of the term, none of them were humanists. The few who professed Greek and Latin in the colleges of the East obviously belonged to a tradition that was not of Rensselaer. Others, however, may properly be claimed as its own. As early as 1858, the Institute maintained a professorship of English, undoubtedly one of the first in America. In view of this fact, it is not surprising that several of the alumni have been drawn into similar positions. The most notable, possibly, was Joseph Thomas ('30), compiler of several gazetteers and author

of the *Universal Pronouncing Dictionary of Biography and Mythology* (1870–71). Leaving Haverford, he became professor of English Literature at Swarthmore in 1873. Long before this date, however, he had, while in India and in Egypt, made a special study of Sanskrit, Persian, and Arabic. In point of time, therefore, he was the first of several graduates who devoted themselves to the languages and literatures of the East. Two years after he left the Institute, Samuel Wells Williams ('32) declined an assistant professorship at his *alma mater* in order to accept the directorship of the press of the American Foreign Mission Board at Canton, China. His subsequent career as interpreter to Commodore Perry in Japan and as professor of Chinese and Oriental literature at Yale College is well known. Of his numerous works, the most famous, possibly, are *The Middle Kingdom* (1848), which has been widely read in various editions, and *A Syllabic Dictionary of the Chinese Language* (1874), which is his most enduring monument. If

Williams may be said to have become an orientalist by choice, Fitz Edward Hall ('42) may be said to have become one by chance. When he reached India in his search for a runaway brother, he had no idea of studying either Sanskrit or the vernacular, much less of occupying a professorship in the Benares Government College. Once interested in education, however, he devoted himself unreservedly to the administrative problems of the Central Provinces. Removing to England, he became professor of Sanskrit, Hindustani and Indian jurisprudence in King's College. Appointed by the Civil Service Commission examiner in Hindustani, he succeeded Max Müller as examiner in Sanskrit and later became examiner in English as well. The last examinership is a landmark in his career. Distinguished for his monographs on Sanskrit, he turned his attention almost wholly to English and in the last thirty years of his life made for himself a niche among the philologists of his day. Of his work in philology, the most valuable is

that connected with the *Oxford Dictionary* and the *English Dialect Dictionary*. In this curious combination of the languages of the East and West—a combination that sprang from the etymologies in the early courses at the Institute—the alumni have made their most enduring contribution to the humanities.

If the term be extended, however, to embrace all studies of cultural value—if it be extended to cover those belonging to the primary and secondary schools—it will be found that their contributions have been as various as their careers. Two of them, for instance, were prolific and, apparently, useful writers on the pedagogy of the lower grades. Since Van Rensselaer's primary aim had been the development of teachers to disseminate the New Learning, a considerable number of young men educated in Troy before 1875 entered the secondary schools. Though most of them made their mark as masters of the sciences, many were drawn into the routine of administration. Of forty

whose careers I have been able to follow, over half became heads of academies. In such widely separated cities as Albany, Brooklyn, Chattanooga, Cincinnati, Dayton, Erie, Hartford, and New York, they exercised the duties of principalship. Ten also were superintendents, responsible for the conduct of both primary and secondary schools. In institutions of higher learning, like the normal schools at Salem and St. Louis, they were also administrators. Though the presidents, directors, and deans who were graduated from Rensselaer before 1890 were usually connected with technical colleges and professional departments, others, even more eminent, devoted their energies to the needs of the districts in which they lived. In a dozen cities as important as Ann Arbor, Brooklyn, Grand Rapids, and New York, they presided over the local boards. In the great States of California, Illinois, Massachusetts, Michigan, and New York, they were often regents; and in three of these—California, Illinois, and Michigan—they were also

superintendents of education, responsible for the cultural development of the commonwealth. Though they impressed their ideals most definitely upon the universities of the West, to which, as I have explained, they carried the evangel of the New Sciences, if not the New Humanities, they touched also the colleges of the South. In one state—Kentucky—the organization of the university followed the lines laid down in his report by the distinguished alumnus who advocated its establishment. His breadth of vision, embracing the needs of the whole community, is symbolic of that of his fellows who raised the fiery cross of the New Education, which, in spite of its manifest defects—its crudeness and its utilitarianism—may yet make possible a perfect democracy.

CHAPTER VI

THE PUBLIC SERVICES

THE career of Mr. Hoover, Secretary of Commerce and an honorary graduate of the Institute, has often been cited as an augury of a new era among scientists and engineers. It has always been assumed that they have been lax in their public duties; that, more than the members of other professions, they have been so engrossed in their specialties that they have been negligent of their responsibilities as citizens. Like most generalizations of this kind, the belief probably rests on nothing sounder than popular opinion. It is doubtful whether it has been substantiated by a statistical inquiry. Indeed, it is doubtful whether, except in the case of Rensselaer, materials for such an investigation are yet available. Of institutions devoted primarily to science and engineering, it alone can point to a consecutive history of a hun-

dred years. It would be strange, therefore, if the records of its graduates in peace and in war should not throw some light upon the question which has been raised in this paragraph.

In the last chapter I have spoken of their services in the cause of education. These are symbolic of the manner in which they have accepted the opportunities of community life. As illustrative of the range of their interests, it may not be out of place to recall the activities of Alfred Tredway White ('65), architect and philanthropist, whose achievements are suggested by the dormitories which bear his name. Executive and idealist, he learned how to temper business with humanity. Profitable as his tenements became, they were merely symbols of his devotion to the masses of the metropolis. With his name may well be linked that of Nelson Peter Lewis ('75), for many years chief engineer of the Board of Estimate and Apportionment of New York City. Long responsible for the development of the greatest municipality in

America, he became increasingly interested in the problems of community life under modern conditions. Though his attitude was more distinctly professional than that of White, his services as director of the physical survey undertaken by the Sage Foundation were actuated by a similar desire to increase the comfort and happiness, and so to release the energies and capabilities, of the millions who jostle one another in the congested centres of population. As the most eminent municipal engineer of the continent, he helped to establish the honorable standards which the public exacts from those in whom it reposes confidence. His life is sufficient evidence that technical attainment is no bar to community service.

Likewise, in the realm of politics—the realm in which specialists are most often accused of indifference—there appears to be little ground for the accusation of selfishness. In the first sixty years of its existence, during which time the graduates of the Institute were still few in number, they served not

only as heads of bureaus and commissions, where their functions were largely professional, but also as presidents and mayors of municipalities. Two of them directed the fortunes of great cities. In the state legislatures, also, it is easy to trace their footsteps. In at least nine states—California, Maryland, Michigan, New York, South Carolina, Utah, Vermont, Virginia, and Wisconsin—they were members of the lower house. Within a decade, at times, there were several representatives in a single assembly. In the newer commonwealths especially, they exerted no little influence upon educational affairs. In addition to those graduates who became state senators or congressmen, one, George Robert Dennis ('39), president of the Eastern Shore Railroad, became United States Senator from Maryland. If to these are added those who served—often with distinction—as members of constitutional conventions, as comptrollers or lieutenant-governors of states like Maryland and New York, as consuls-general or special commis-

sioners—and they were not a few—it is evident that in local and national politics they have played an honorable part. Though it is probable that the increasing specialization of the last forty years has affected materially the number who have entered public life, the record as it stands makes clear that Mr. Hoover's career has been notable in degree and not in kind.

In national crises, too, the graduates of the Institute have met their responsibilities like other citizens. During the Civil War they were chaplains and surgeons. In fact, Reed Brockway Bontecou ('42), who established the first general hospital, became the chief medical and surgical historian of the period. Nevertheless, the most important contributions made by the alumni were naturally in engineering. As Rensselaer and West Point, with a limited number of graduates, were the only notable institutions offering special courses in applied science, their sons were naturally thrust into positions of leadership. Of those from Troy, many rendered more

than ordinary service. On the Atlantic, along the Mississippi, and by the Pacific, they were to be found in every corps. Ten were lieutenant-colonels, or colonels, in charge, probably, of engineering regiments; four were adjutant-generals. Among these and others, it might be possible to single out those, like Anthony Walton White Evans ('36), who constructed the defenses of New York, or George Frederick Ells ('56), who built the Watervliet Arsenal, who afterward rose to eminence in civilian life. Such a procedure seems altogether pointless. Rank has no monopoly of devotion; and from the dust-covered alcoves of the library spring the figures of many gallant gentlemen, now forgotten, who once moved a division when advance seemed hopeless, or who once matched their skill with that of their classmates in a hostile redoubt, and who, when their duty was done, returned to their laboratories or their offices to take up again the routine of research or administration. Of those who made the army their profession—of the five, for instance, who be-

came brigadier-generals—I do not intend to speak. Regarding the World War, of which the memorial tablet in the Pittsburgh Building is a constant reminder, something, however, should be said. Of the six hundred Rensselaer men who served in the forces of the United States, one can be mentioned without invidiousness—Henry Wilson Hodge ('85), colonel, assistant chief engineer, and director of roads, headquarters staff, in the American Expeditionary Force. His knowledge and energy did much to make possible the despatch which determined the success of the Allied troops.

Devoted and useful as have been the services of the alumni in the army of the United States, it is doubtful whether they have been more distinguished than those in the navy. With Annapolis, the Institute has always been closely connected. As a pathfinder it sent to it half a dozen professors of mathematics, physics, or engineering. Moreover, in addition to the graduates who have been drafted from time to time for special

purposes, many of the alumni have entered the technical branches of the service. Those who became chief engineers have left many monuments of their genius in the design of both ships and machinery. A number, too, have made definite contributions as heads of various bureaus. Charles Whiteside Rae ('66), for example, engineer-in-chief and rear-admiral, had charge of the Bureau of Steam Engineering. In the last fifty years the Bureau of Yards and Docks has been directed by three graduates, also ranking as rear-admirals. Indeed, the Corps of Civil Engineers was practically organized by alumni. Neither in peace nor in war have they been found wanting.

The career of Mr. Hoover is a reminder and not a portent.

CHAPTER VII

CANALS AND RAILROADS

One of the most striking features of the nineteenth century—one which influenced materially the destinies of countries and even continents—was the general advance in methods of transportation. Because of its unique place among educational institutions in the United States, Rensselaer became the recognized leader of this movement. In the construction and operation of canals and railroads, as well as of ships and engines, of which I shall speak in another chapter, its graduates were among the first in the field.

With the earliest waterways—those described in *A Connected View of the Whole Internal Navigation of the United States*, a curious volume published in 1826—they had nothing to do. Within a decade, however, they were engaged as divisional engineers on the new Erie Canal. Some of the locks which

they constructed long seemed stupendous. A little later, when Congress voted an appropriation for the improvement of the South Pass of the Mississippi, George William Read Bayley ('38) was selected by James Buchanan Eads to take charge of the undertaking. As engineer of jetties and also commissioner of levees, he became, with Eads, one of the two authorities on the Mississippi. Elsewhere, too, the alumni did distinguished work. John Pierpont ('69), grandson of the poet, who surveyed the harbors of Superior and Duluth, charted a route from the Mississippi to the Great Lakes. Afterward Lyman Edgar Cooley ('74), head of the department of engineering in Northwestern University, became chairman of the Engineering Committee of the Sanitary District of Chicago. Moreover, on the Drainage Canal, Jesse Lowe ('85) was jointly responsible for many of the details of design and construction. With many smaller undertakings the alumni were also associated.

In recent years, however, the most notable

enterprise with which they have been connected is the Panama Canal, with which they have been identified from the beginning. As early as 1871, Estévan Antonio Fuertes ('61), who afterward established the colleges of engineering in Cornell University, was appointed engineer-in-chief of the United States expeditions to Tehuantepec and Nicaragua to determine the practicability of constructing a ship-canal across the isthmus. Within the next few years Antonio Garcia Menocal ('62)—like Fuertes, a native of the Spanish West Indies—explored the possibilities in Panama as well as Nicaragua. Under the circumstances, it was natural that he should have been appointed by the United States to represent it at the International Scientific Congress at Paris in 1879 and that he should have been called upon to explain to its members the relative merits of the two projects which he had investigated. As a result, he organized the Maritime Canal Company, which was incorporated by Congress in 1899. With the work of the Interoceanic Canal

Company, also, the alumni were closely associated. Indeed, they were active at the Isthmus until the completion of the Panama Canal. One of the three members of the Nicaragua Canal Board, appointed in 1895, was a distinguished alumnus, a rear-admiral in the United States Navy. Moreover, when the Isthmian Canal Commission was established a few months later, one of its members, another eminent graduate, professor of civil engineering in Columbia University, was elected to each of the two committees of three chosen to study the rival routes and, in due course, was appointed to the Board of Consulting Engineers. Nor was the connection of the graduates with the Canal limited to their reports; for another alumnus, also a rear-admiral in the United States Navy, served as a member of the commission during the period of construction. From the beginning, therefore, the Institute was connected in a peculiarly intimate manner with one of the greatest tasks completed since its establishment.

Striking as were the services of the graduates at Panama, they have been overshadowed by their records on the railroads of the United States. Though they were apparently not connected with any of the experimental lines established about 1830, they were everywhere influential during the period of expansion between 1840 and 1890. During this time they were responsible for the construction of nearly three-quarters of the mileage in America. During this time, also, over fifty of them were chief engineers of the companies by which they were employed. In this way they served not only such roads as the New York Central, in the United States, and the Grand Trunk, in Canada, but also others in China, Japan, Spain, and the republics to the south. Nearly fifty, moreover, were superintendents or general managers of railroads as widely distributed. In both construction and operation they affected profoundly the course of civilization in the two Americas.

Though it is impossible to mention all those

—over four hundred in number—who served their generation in this manner, the lives of two of them will illustrate those of their fellows.

One of the first alumni to win distinction was Anthony Walton White Evans ('36), who was graduated at a time when development was just beginning. Almost immediately he turned to the field with which his name is inseparably linked. After an apprenticeship in the United States, he was called upon, in 1850, to take charge of the Copiapo Railroad, in Chile. On its completion, he became chief engineer of the Arica and Tacna Railroad, in Peru, and, in 1856, after its construction, chief engineer of the Southern Railroad. Returning to the United States on the outbreak of the Civil War, he directed the defenses of New York. When peace was declared, he was commissioned by the Secretary of the Interior to establish standards for the new roads on the Pacific. In the meantime, however, he had become president of the United States Petroleum Company and

of the Spuyten Duyvil Rolling Mill Company; and henceforth he extended his interests to the details of manufacture as well as of design. As official adviser to the governments of Chile, Costa Rica, Peru, Mexico, Australia, and New Zealand, he supplied immense quantities of equipment to the lines in these countries. Among the numerous structures which he designed was the famous Verrugus Viaduct—destroyed by floods in 1889—on the Lima and Oroya Railroad, in Peru, which stood nearly six thousand feet above the sea. Nor were his labors limited to the Americas; for he was invited to report upon railroads in Great Britain, Germany, and Russia. An intimate associate of scientists and men of affairs on four continents, he was one of the first Americans—now a goodly company—to acquire wealth and leisure for artistic pursuits. An antiquarian of note, he accumulated many rare books and valuable paintings, thus charting a course which has contributed materially to the culture of the metropolis. In all, his life approximated

closely to the colorful ideal which moves the average freshman who to-day elects a course in civil engineering.

Though the early graduates of the Institute often enjoyed as varied an experience as that of Evans, most of them naturally did their work in North America. Fairly typical of these was John Fiske Barnard ('50). On graduation, he went to Canada, where he was connected with the construction and operation of a number of the small lines which were eventually merged as the Grand Trunk. For a couple of years he was superintendent of the Buffalo and Lake Huron division of that road; and, in 1866, he became chief engineer. Later he served in the same capacity, or as general superintendent, on four roads in the United States. Finally, he was elected president of the Ohio and Mississippi Railroad. In the meantime, he had become head of many other corporations; and, as might be expected, the rest of his life was devoted almost exclusively to executive concerns.

As administrators, the alumni have naturally made for themselves names which are more generally known than are those of their fellows who have spent their lives in the technicalities of their professions. In addition to those who have become vice-presidents, many have been presidents of important railroads. William Clement ('35), of the Cincinnati Southern; Luiz da Rocha Diaz, Jr. ('60), of the Pecaoha Araxa Railway, of Brazil; Alfred Walter ('72), of the Lehigh Valley; Souichiro Matsmuto ('76), of the Imperial Government Railways of Japan, and Theodore Voorhees ('69), of the Philadelphia and Reading, filled such positions, sometimes on several lines in succession. A study of conditions on one road such as the Pennsylvania will, however, give a clearer idea of the great and enduring services which the graduates of the Institute have rendered to the people of the United States.

Most of its lines had been located and constructed by alumni, who, as I shall show in the next two chapters, rolled many of

the rails, built many of the bridges, and manufactured many of the engines required for their equipment. Moreover, Strickland Kneass ('39), who had been connected with the preliminary surveys, erected, at Altoona, the first shop and engine house. As chief engineer of the newly consolidated city of Philadelphia, by which he was preemptorily drafted, he planned the entire drainage system of the metropolitan district. After fifteen years of distinguished service, he returned to the Pennsylvania as assistant to the president; and, from this position, he rose to the presidency of such subsidiaries as the Pennsylvania and Delaware and the Philadelphia and Trenton as well as to that of the Eastern Railroad Association. Not unlike his career was that of George Brooke Roberts ('49), graduated exactly ten years later. Roberts, who had been a rodman on the earliest expeditions, who had been engineer-in-charge-of-construction on several important divisions, and who had been successively fourth, third, second, and first vice-president,

became, in 1880, president of the Pennsylvania and its allied companies. As he helped to lay the foundations of the system, Alexander Johnson Cassatt ('59), graduated, again, ten years later, helped to rear the superstructure which has made it one of the great corporations of the world. Like Roberts, he began as a rodman, directed the construction of various branches, and served as divisional engineer, finally becoming general superintendent and, afterward, vice-president in the different grades. When Roberts was promoted to the presidency in 1880, he became first vice-president in his stead. As head of the New York, Philadelphia, and Norfolk Railroad, he acted as representative of the United States on the International Railway Commission, of which he was chosen president; and, in 1899, he succeeded to the presidency of the Pennsylvania and its subsidiary organizations. An executive of wide and varied interests, he immediately inaugurated a policy of expansion, beginning work on the tunnel under the Hudson and on the terminal

in New York City. The strategic position of the road to-day is largely a monument to his foresight and initiative. It is no less a monument to a Rensselaerian succession which has been paralleled on many roads in the Union.

Since I have not attempted to deal with the work of more recent graduates, some of whom have achieved the highest distinction, I have probably said enough to emphasize the part which the older alumni played in the development of railroads in America. They were promoters, however, as well as administrators. Though none of them can be listed among the half dozen "malefactors of great wealth" whose names are associated with the era of expansion in the West and of finance in the East, their services, as symbolized by the career of Edwin Bryant Crocker ('33), have been of lasting value to the commonwealth. Associated as counsel and general agent with his brother, Charles Crocker, with Leland Stanford, and with Collis Potter Huntington in the construction of the Central

Pacific, he was largely responsible for the success of that momentous undertaking. Like Evans, also, he was one of the first of the early magnates who devoted their fortunes to the advancement of the arts, leaving, at his death, the finest private gallery and collection in America. In summarizing his labors as typical of those rendered by many other alumni, I cannot do better than quote the words—a little grandiloquent but, nevertheless, essentially true—written of him by the people of his adopted state: he "will not need a monumental shaft to perpetuate his memory; his name is inscribed on the iron lines over the broad fields of California; it is cut in our mountains; it is imprinted on the everlasting rocks, and there it will remain forever."

CHAPTER VIII

STRUCTURES AND MECHANISMS

In the long line of dormitories stretching across the east end of the campus is a group bearing the names of four great bridge-builders—Buck, Cooper, Roebling, and Macdonald—who have been graduated from the Institute. Their achievements, which are familiar to millions who have never heard of their *alma mater*, are symbolic of the accomplishments of the alumni in many fields of engineering. Of these, the structures which they have built and the mechanisms which they have invented are naturally the most spectacular.

Naturally, also, the structures which they have built—the Ferris Wheel, for example, named after its designer, George Washington Gale Ferris, Jr. ('81), and the Brooklyn Bridge, to which I shall turn in a moment—can be treated more easily in a sketch of this

kind. Instead, therefore, of attempting to deal with the mechanisms which they have invented, and which are suggested by the character of the industries listed in the next chapter, I shall merely mention the work of a few graduates whose inventions have been connected in a peculiar way with the development of engineering practice. Several names at least will spring at once to the mind of any practitioner.

Shortly after graduation, William Gurley ('39), who had served an apprenticeship in one of the small bell foundries for which Troy was famous before the Civil War, began the manufacture of engineers' and surveyors' instruments in the same city in partnership with Jonas Phelps. Six years later, when Phelps retired, he was joined by his brother, Lewis Ephraim Gurley ('45), and with him organized the firm of W. & L. E. Gurley. For many years it has been the largest manufacturer of the instruments in which it has specialized. It is safe to say that there is no country in which they are not known. In

addition to the development of such devices as transits, compasses, meters, and levels, the founders of the company, who established the honorable tradition of public service—educational, philanthropic, and political—maintained by their successors—were connected individually with the determination of exact standards of measurement in the United States.

If I were to treat fully this phase of the subject, I should need to describe at length the inventions of an eminent graduate who is still living to enjoy the fruits of his labors. The Emery testing machine, designed and constructed by a member of the class of '58, is world famous. First and, historically, the most notable of these machines is that at the Watertown Arsenal, which is capable of measuring accurately the strains induced by loads up to 800,000 pounds. The greatest—constructed for the Bureau of Standards—has a tensile capacity of 1,150,000 pounds and a compressive capacity of 2,300,000 pounds. These machines, as well as many others in-

stalled in private plants and public laboratories, have contributed materially to the advancement of engineering practice.

In this connection a striking figure is Edwin Thacher ('63), who first aroused interest in the slide rule in the United States. The cylindrical rule which he introduced in 1881 was followed, in 1900, by a flat rule which was long regarded as superior to all others. Like the two testing machines which I have described, these two rules marked an epoch in mechanical calculation. Thacher, however, did not limit his interests to such mechanisms; for he became one of the most successful bridge-builders of his day. As chief engineer of the Keystone Bridge Company, and afterward as a member of several important firms, he not only constructed many bridges on orthodox lines but also introduced the concrete steel arch bridge type, of which the Kansas River Bridge, at Topeka, was long the largest of its kind. His career, therefore, leads directly to the next topic.

With the introduction of cast-iron bridges,

coincident with the rise of railroads, Rensselaer became a source of inspiration for the young men who were to design, manufacture, and erect the bridges required to meet the needs of a growing population and a rapidly expanding traffic. Though Squire Whipple, who in 1840 built the first cast-iron bridge, was not a graduate of the Institute, John J. Murphy, who was associated with him in the introduction of pin connections, was a member of the class of 1846. Not long after graduation he designed a suspension bridge with a vertical truss—the first of its kind—on the Mohawk River; and in 1858–59 he built, for the Lehigh Valley Railroad, the first truss bridge which was pin-connected throughout. Finally, in 1863, after a varied experience, he erected on the Lehigh River another Murphy-Whipple bridge in which he used wrought iron for both the posts and the top-chord sections. This was the first American truss bridge in which the tension and the compression members were of wrought iron. Not only in the design and erection but also

in the manufacture of bridges the alumni were leaders; for one of Murphy's classmates, Percival Roberts ('46), purchased Whipple's patents and established the Pencoyd Iron Works, afterward the Pencoyd Steel Works, which was the first iron-bridge building company in America. As president of this corporation, he fabricated the materials for and, in many cases, erected most of the earliest bridges on the Illinois Central, the Pennsylvania, the Lehigh Valley, and other railroads. In the development of short-span bridges erected before the invention of steel, the Institute was without a competitor.

Even in the next period, an age of individualism marked by the construction of long-span steel bridges, it remained supreme. One of the earliest long-span bridges is that at Niagara, for which Charles Henry Fisher ('53), chief engineer of the New York Central Railroad, was consulting engineer. In 1877, it was reconstructed by Leffert Lefferts Buck ('68), who had won his majority in the Civil

War before he entered the Institute. Later, in 1880, after a distinguished career in South America, he replaced the wooden superstructure with steel fabricated by the Rochester Bridge Works, under the presidency of John Alden ('72). In 1885 he renewed the towers; and in 1896 he designed and erected, with the assistance of several other alumni, the present two-hinged, spandrel-braced arch bridge, which contains the longest span of its kind, and for which the materials were manufactured by the Pencoyd Steel Works. Although he constructed the steel arch bridge at Niagara Falls, his greatest achievement is the Williamsburg Bridge, in New York, containing the largest suspension-bridge span ever built, which he designed and erected with the aid of one of his classmates, Othniel Foster Nichols ('68), and a number of other graduates. Of the materials in the bridge, the cables were supplied by the John A. Roebling Sons Company, under the presidency and vice-presidency of Washington Augustus Roebling ('57) and Charles Gus-

tavus Roebling ('71). In design and manufacture the alumni have often been associated in this manner.

The career of Theodore Cooper ('58)—next in age to Buck—was similar in many respects. Unlike Buck, however, he served in the navy during the Civil War and became an instructor at Annapolis after the Academy was reopened in 1865. Resigning in 1872, he entered the employment of the Midvale Steel Works and superintended the erection of the St. Louis Bridge. After a period of service with the Keystone Bridge Company, he established himself as a consulting engineer, designing many notable bridges, especially for the railroads of the United States, by which he was often retained. Among the structures with which he was connected professionally is the Washington Bridge over the Harlem River, in New York. In its construction, he maintained with his fellow alumni the relationship between Murphy and Roberts which has been duplicated on many of the greatest bridges in America.

One of these is the famous New York and Brooklyn Suspension Bridge. On account of the length of its span and the difficulty encountered in its erection, it is one of the celebrated engineering feats of the nineteenth century. Designed by John Augustus Roebling, who had been educated at Berlin, it was built by his son, Washington Augustus Roebling ('57). Resigning from the army after the Civil War with the rank of colonel, the latter, who previously had been associated with his father on the Pittsburgh Suspension Bridge, joined him on the Cincinnati and Covington Suspension Bridge. Upon his father's death, shortly after its completion, he proceeded with the half-finished plans for the bridge across the East River. Amply equipped for the task by his experience as a military and civil engineer, he was able, in addition, to draw upon many of his friends at Rensselaer as well as upon the resources of the great wire company of which, at eighty-seven, he is still president. The huge cables in his masterpiece thus

represent the kind of correlation which I have already emphasized.

Like Roebling, Charles Macdonald ('57), a classmate, graduated with him one year before Cooper, is still living to enjoy the rewards of a long and successful career. As president of the Union Bridge Company, he has helped to build many notable bridges. Among them is the Poughkeepsie Bridge, across the Hudson, and the Hawksbury River Bridge, Australia, in the design of which he was assisted by his classmate Roberto Escobar ('57). The fact that his work has been done as head of a large corporation marks the beginning of a new era—a period of coöperation in which the individual is overshadowed by the organization of which he is a part. It marks, also, an era of standardization which precludes the element of personality so characteristic of the other periods to which I have referred.

Before turning to the bridges constructed by great corporations, I must mention a few alumni who deserve to be remembered. By 1900 at least a hundred had made for them-

selves honorable names as builders of bridges. As late as 1890 it was said that there was no great bridge in the United States which they had not designed or which they had not helped to manufacture or erect; and there is no reason to doubt the accuracy of this statement. Alfred Pancoast Boller ('61) and Henry Wilson Hodge ('85) designed and constructed the Municipal Bridge across the Mississippi River, at St. Louis, which contains what were once the longest simply supported spans, and also erected the Monongahela River Bridge, at Pittsburg, the largest railroad cantilever bridge in the Union, as well as the great Duluth-Superior Bridge. Other graduates—some of them highly distinguished—have helped to design bridges like that over the Missouri River at East Omaha or have drawn plans for others like the Red Rock Cantilever Bridge over the Colorado on the Atlantic and Pacific Railway and the Hawthorne Avenue Vertical Lift Bridge at Portland, Oregon. In all, the record of their achievements is an imposing one.

To the traditions which they have estab-

lished the great bridge companies are the legitimate heirs. In these corporations the graduates of the Institute have long been dominant. The president of the Edge Moor Bridge Company, which erected many bridges in the Middle West, was Henry Grant Morse ('71). Among those which it designed, fabricated, and erected is the Norfolk and Western Railway Bridge over the Ohio River. The Phœnix Bridge Company and the Union Bridge Company, both especially dependent on the alumni, I have already cited. Another corporation under the presidency of an alumnus is the Louisville Bridge and Iron Company, which has built the Kentucky and Indiana Company Terminal Railroad Bridge over the Ohio River. Others, still, are the Osborn Engineering Company, which has erected, from plans drawn by alumni engaged as consultants, the concrete steel Y bridge at Zanesville, and the Chicago Bridge and Iron Company.

Any effort, however, to indicate the number of firms in which the graduates are

charged, as superintendents, managers, or engineers, with the details of administration and construction would be little more than a catalogue of the leading corporations of the United States. Their influence, however, has not been limited by their personal contacts; for many of them have made valuable contributions to the literature of the subject. Cooper's specifications for iron and steel highway bridges were the most widely used of their time. Another alumnus—still living—who has made elaborate experiments on the use of nickel as an alloy of steel, has helped to establish nickel-steel as an indispensable material in modern bridge building. Moreover, in keeping with the origins of the Institute, it has often sent its most illustrious sons to other institutions to establish there traditions which may conceivably challenge its own.

Though it is unlikely, under present conditions, that Rensselaer, or any other school of engineering, will assume the position once held by the Institute, its graduates are cer-

tain to be drawn more generally into other fields of structural engineering. In the use of steel and concrete in building construction, they have made more than a beginning. Many large undertakings have been carried through by them. The great plant of the Firestone Tire and Rubber Company at Akron was designed by the Osborn Engineering Company. That of the Union Carbide and Carbon Corporation at Niagara Falls was erected under the direction of its president, a member of the class of 1876; and the mill of the United States Steel Corporation at Gary—the largest billet and rail mill ever constructed—was designed and also built by the United Engineering and Foundry Company, of which the president is a member of the same class. Among corporations officered, and largely manned, by more recent graduates are the Foundation Company and Jarrett-Chambers Company, of New York. The first of these designed and constructed the foundations for the Woolworth Building, the tallest in the world, and

the second those for the new Standard Oil Building on New Street, New York. To skill in laying foundations they have also added skill in raising superstructures; for at the World's Columbian Exposition, of which the chief engineer was Edward Clapp Shankland ('78), a pioneer in the development of the modern skyscraper, the Edge Moor Bridge Company fabricated for the Manufacturers' Building the largest roof arches ever erected. In structural engineering, therefore, the alumni have already established an enviable record.

Though the Institute, which has always hesitated to introduce courses which it cannot maintain at the highest standard, has never felt able to establish a distinct curriculum leading to a degree in architecture, the inclusiveness of the courses in civil engineering has led many alumni into the field of design, in which, as in the building of bridges, they have often collaborated with their fellow graduates. In addition to innumerable structures such as the Terminal Station of the

Philadelphia and Reading Railway Company, designed by the three Wilson Brothers, graduated between 1855 and 1866, and constructed by the Phœnix Bridge Company, under the presidency and superintendency of other graduates, and the huge Terminal Elevator at Sydney, Australia, they have designed, and often erected, notable dwellings, hotels, churches, and colleges. In a previous chapter I mentioned Alfred Tredway White ('65), philanthropist and architect, who planned the first tenement houses in Greater New York. In view of this fact, it may be interesting to know that the first apartment house of the curtain wall type was designed by the chairman of the board of directors of the National Bridge Works, who was graduated in 1892. Among the hotels which the alumni have designed are the Blackstone, of Chicago, and the St. George, of Brooklyn. Of churches, two of great historical interest are the New Old South Church, of Boston, designed by Charles Amos Cummings ('49), and the Mormon Temple, at

Salt Lake City. Like the Young Men's Christian Association in New York, and the Drexel Institute, in Philadelphia, these two churches, so different in tradition and appearance, are not only suggestive of the variety of the problems with which the alumni have grappled successfully in the past but are also indicative of the tasks which they are likely to undertake in the future.

CHAPTER IX

BUSINESS AND INDUSTRY

EVEN a casual study of the careers adopted by the graduates of the Institute will emphasize the variety of their interests. There is no phase of business or industry which they have not essayed. Many have been merchants. Not a few have been bankers or brokers. Others have been miners. Two hundred have been manufacturers—presidents or vice-presidents of the corporations with which they have been associated. As many more have been managers or chief engineers of similar enterprises. A review of their activities is therefore likely to be as motley as Joseph's coat of many colors.

In attempting to correlate their accomplishments in the world of affairs, I shall touch first upon their achievements in business. Though I have not followed any economic classification, it may be advisable to adopt one at this point. In the case of the

"carrying industries" so called, I have already considered the services of those who have been concerned with transportation. I shall now deal with the services of those who have been connected with the purveyance of goods and the maintenance of credit. Here, as often, there is an embarrassing wealth of material. Anyone with imagination who examines the character of the firms mentioned in the next paragraphs will realize how impossible it is to group systematically the mercantile and financial organizations into which their heads have inevitably been drawn. They have been directors of so many companies that any enumeration would be meaningless. Some have been presidents of banks or owners of seats on the great exchanges. James Wallace ('37), who organized the New York Produce Exchange, of which he became president, and who helped to found the New York Life Insurance Company, became head not only of the New York Warehousing Company but also of the New York Guaranty and Indemnity Company. In view

of the tendency among the alumni to seek advanced and highly specialized training in graduate schools of business administration, the success of financiers like Wallace is an interesting commentary on the adaptability of the courses offered by the Institute. It seems certain that in the future large numbers of students who intend to enter colleges offering higher degrees in commerce and management will elect a liberal curriculum in engineering as the safest foundation for further study. Even a glance at the multifarious interests of the alumni will emphasize the reasonableness of this conjecture.

Of the four "extractive industries," mining has naturally made the greatest appeal. Long before Rensselaer established a course leading to a degree in this field, or the Colorado School of Mines had received its charter, its graduates had turned in considerable numbers to Freiburg, Liège, and Paris. Many, it is true, succeeded without their aid. In the development of the coal and iron resources of the country, they were often

content with the knowledge which they had acquired at the Institute. John Allston Wilson ('56), distinguished as an engineer and architect, exploited successfully the bituminous deposits of Pennsylvania soon after he left Troy; and neither Ario Pardee, Jr. ('58), who served as a brigadier-general in the Civil War, and who eventually became president of the Allentown Rolling Mill Company, nor Calvin Pardee ('60), also an officer in the War and an influential operator, had enjoyed the advantages of graduate study. Nor had men like Irving Ariel Stearns ('68), who constructed many of the collieries in the East, any wider background. On the other hand, Walter Crofts ('59), of the Columbia and Hocking Coal and Iron Company, had spent a couple of years in Saxony; and Richard Pennefeather Rothwell ('58), whom I shall mention again, had been a student in France as well as in Germany. As a rule, the alumni who became interested in coal or iron devoted themselves either to administration or to research.

In the mining of gold and silver, copper and zinc, the same cleavage is apparent. Through their good fortune in the California gold rush, not a few of the graduates were able to establish themselves on the Pacific, where they became prominent and public-spirited citizens. After the War, a larger number turned to the silver, copper, and zinc fields of the West. In Arizona, Colorado, Idaho, Montana, and Mexico, they served as superintendents or managers of important mines and reduction plants. Cassimer Whitman Boynton ('56), for example, who designed the water system of San Francisco, became a specialist in the treatment of silver ores. His classmate William Henry Martin ('56) was long associated with one of the largest copper companies; and Arthur Brice de Saulles ('59), who, like many other graduates, had studied at the Imperial School of Mines in Paris, is still remembered in connection with the zinc industry of the East. With his name may be linked that of William Newton Symington ('61), who spent several

years at Göttingen and Freiburg, and who, as director of many large organizations, dealt with almost every aspect of the mining industry. Ordinarily, however, the interests of the two groups which I have mentioned were seldom coincident.

Illustrative of the differences between them are the careers of two classmates—Ario Pardee, Jr. ('58), and Edward Pennefeather Rothwell ('58)—one primarily a man of affairs, the other primarily a technologist. Of the activities and benefactions of the Pardee family, I do not need to speak. They are too well known to require comment. Rothwell's claims to distinction, however, may not be so familiar. Like Charles Macdonald ('57) and several other eminent graduates, he was a Canadian by birth, leaving Trinity College, as Macdonald had left Queen's, to enter the Institute. After four years at the Imperial School of Mines in Paris and the Mining Academy in Freiburg, he returned to Canada, and afterward to the United States, occupying various positions in the anthracite

region of Pennsylvania. During this period he made many improvements in coal breakers, in furnaces for roasting ores, and in methods for chlorinating gold pyrites. Later he prepared a series of contour maps which have since been adopted by the United States Geological Survey. In the meantime, however, he had established the most lucrative practice in America; and though he continued to examine and to report upon properties in all parts of the world, he became increasingly interested in the development of his profession. Because of this interest, he acquired control of the *Engineering and Mining Journal*, which, as editor, and also as head of the Scientific Publishing Company, he made the leading periodical of its kind. Nor were his activities limited to his editorship; for, in 1871, he organized the American Institute of Mining Engineers, of which he was afterward elected president. Since James Curtis Booth ('31) was the first to suggest the possibility of determining the treatment of ores by means of chemical analyses; since he was the

first to solve the problems connected with the refining of cobalt and nickel as well as the first to establish works for the application of the processes which he had invented; since he also introduced original methods for refining gold and silver, and since other alumni, like William Gibson Sharp ('76), president of the United States Smelting, Refining and Mining Company, have been officials in numerous corporations, the graduates of the Institute have made no inconsiderable place for themselves in a branch of engineering in which it is no longer supreme.

In the manufacturing industries, on the other hand, Rensselaer has more than held its own. Those connected with chemicals and oils—first on the schedules of the Tariff Commission—were dominated by the graduates of the Institute at an early date. Since five of the professors in the first decades of its history had studied in Germany, and since their students naturally followed in their steps, they really initiated this group of industries. It is true that before their time

European technicists had organized factories in the United States; but they were the first native Americans to establish any of commercial importance. As before, the names of Booth and Eben Norton Horsford ('38) overshadow those of their fellows. Booth, as I have indicated, was the most eminent chemist of his day. In his laboratory—perpetuated by the well known firm of Booth, Garrett & Blair—he developed many original procedures. As Prevost Smith has pointed out, he probably introduced the polariscope in the analysis of sugar and molasses. Moreover, he trained a whole school of manufacturing chemists and university professors. Horsford, also, was a pathfinder. As president of the Rumford Chemical Works, he made many useful discoveries. Popularly, of course, he is remembered chiefly by the acid phosphate with which his name is associated. As suggested by his career, the alumni had begun to specialize by 1860. Douglas Hyde ('41), for example, served his country well as an expert on powder during the Civil War. Charles

Leverich ('57) engaged in the distillation of wood. Later, graduates like John Hall ('87), chief chemist of the Pennsylvania Salt Manufacturing Company, were to be found in charge of many important laboratories. From the beginning they had been interested in the treatment of oils. John Gardner Ambler ('33) devoted his energies to the purification of cotton-seed oil. James Campbell, Jr. ('43), directed one of the companies formed to utilize the cannel coal of West Virginia. About the same time, Anthony Walton White Evans ('36) became president of the United States Petroleum Company; and to-day the president of the Gulf Refining Company is a member of the class of 1878. This continuity illustrates not only the progress of the Industrial Revolution but also the part taken in it by the alumni of the Institute.

As it is impracticable to treat in such detail all the items in the schedules which I have cited, I shall turn to one particular group that seems especially important. Since the second

quarter of the nineteenth century, the graduates have been a dominant force in the iron and steel industry. In the Central States, on the Great Lakes, and in the South they have been leaders. William Metcalf ('58) was a pioneer in Pittsburgh. Nathaniel Edwards Russell ('70) became chief executive of the Allegheny Iron Company. David Reeves ('72) occupied a similar position in the Phœnix Iron Company. Another alumnus rose to the presidency of the Port Henry Iron Ore Company; and since their day the graduates have served in some capacity in practically every great iron and steel plant in the East. In the Lackawanna Iron and Steel Company, the Bethlehem Steel Company, and the United States Steel Corporation, they have been directors, vice-presidents, or heads of subsidiary organizations. Several have been responsible for important ventures in the Middle West. In Virginia, Frank James Hearne ('67) was long a power; and to-day several alumni are influential in Alabama and Louisiana.

So far, of course, I have been speaking of those companies which depend on raw materials. In reviewing the connection of the alumni with the metal manufactures of the United States, I might well mention such firms as the United Engineering and Foundry Company and the Pittsburgh Steel Foundry Company, both conducted by graduates of the Institute. The companies which depend on materials removed in various degrees from the basic sources are so numerous that I do not propose to analyze them in detail. A few, however, ought to be cited in illustration. The Rochester Bridge Works, founded by John Alden ('72), and absorbed by the United States Steel Corporation, is an obvious example. The John A. Roebling's Sons Company, of Trenton, New Jersey, world famous manufacturers of wire rope, is another. The early locomotive plants, like the Baldwin Locomotive Works, which were owned or directed by the alumni, those that were later merged in the American Locomotive Company, and the National Steel Car

Company, of Canada, also managed by an alumnus, are further instances. The Otto Gas Engine Works, under the presidency of John Saltar, Jr. ('67), of Philadelphia, and the Thompson Electric Welding Company, of Lynn, Massachusetts, under the presidency of Harrison Augustus Royce ('59), may well be added. In all, it is an inclusive and fascinating record.

The corporations using materials even further removed from the original sources are quite as various. Samuel Davis, Jr. ('95), was president of the Locomobile Company of America. The Chicago Bridge and Iron Company, under another alumnus, is one of the largest manufacturers of water tanks. The president of the Federal Signal Company and the manager of the General Railroad Signal Company are both graduates. The presidents of the Ludlow Valve Company and the Eddy Valve Company are also alumni. So, too, were Frederick Grinnell ('55), who organized the General Fire Extinguisher Company, of Providence, a pioneer

in its field, and Daniel Augustus Thompkins ('73), who established the D. A. Thompkins Company, manufacturers of spinning machines. Since I do not wish to make this list a mere directory, I shall not mention many other firms as far removed from one another as the Corona Typewriter Company and the Ingersoll-Rand Company, manufacturers of mining equipment, in which the graduates have been entrusted with the highest administrative duties. Those which I have mentioned ought to establish the fact that there is no phase of the metal industry in which they have not achieved success.

Some phases, like shipbuilding, they have almost preempted. Though I have made no attempt to estimate the number of those who have been attracted to it, the number of alumni who have attained to responsible positions indicates that they have not been few. In the navy, as I have intimated, they have always been influential. In commercial undertakings, also, they have been remarkably successful. In design and construction

they have established many traditions that are likely to endure. Naturally, they did not turn to the industry until the introduction of steel. Since that time they have been active on the Great Lakes, the Atlantic, and the Pacific. In 1886 there were on the St. Lawrence route, according to *Lloyd's Register* for that year, six steel vessels. All these, however, were Clyde-built and unsuitable for the type of cargo handled. In the following year, George Benjamin Mallory ('67), naval architect and engineer, designed the *Owego*, which was built by Washington Irving Babcock ('78), and which embodied the essential features of the modern freighter such as is to-day launched under the superintendency of more than one alumnus. Later Babcock himself designed, for the Chicago Ship Building Company, various passenger ships such as the *Manitou*, long familiar to Lake travellers. To-day, moreover, the president of the Great Lakes Engineering Works is an alumnus. In the East, Henry Grant Morse ('71), who was an adventurer in many fields,

organized the New York Shipbuilding Company, of which he became president, and for which William Gronau ('87) built the yards in New Jersey, at one time unrivalled by any in Europe. A more recent graduate who deserves special mention is Albert Lloyd Hopkins ('92). After a period of apprenticeship in the navy, during which he served as an instructor in the Graduate School of Naval Architecture at Annapolis, and as director of construction and replacement at Key West during the war with Spain, he entered the service of the Newport News Shipbuilding and Dry Dock Company. Successively assistant general manager, general manager, vice-president, and president, he brought to it all powers of a rich and generous nature. Though his death on the *Lusitania* was a heavy blow to the United States, other graduates carried forward the work which he would have done. On the Atlantic, the Foundation Company alone built 118 vessels during the Great War; and on the Pacific, the United Engineering Works, also under

the presidency of an alumnus, met the exigencies of the struggle with similar success.

In emphasizing, in conclusion, the variety of the manufactures in which the alumni have been engaged, I shall return for a moment to the schedules of the Tariff Commission. Of chemicals and oils, the first on the list, I have already spoken. In this group of industries, George Wheeler Carnrick ('74) served as president of the G. W. Carnrick Company, specializing in medicines and prepared foods. Somewhat later, Charles Henry Davis ('83) became head of the Armhein Chemical Company, in his day a widely known firm. Moreover, the president of the Island Petroleum Company and the chief engineer of the Anglo-Mexican Petroleum Company are both alumni. In the manufacture of earthware and glassware, next in order, a characteristic figure is Jason Evans Lippincott ('83), president of the Lippincott Glass Company. The third group, like the first, I have previously discussed. The fourth is represented by the presidents of such firms

as the United States Wood Preserving Company and the American Wood Board Company. Sugar and molasses, also, have naturally attracted a considerable number of students from Latin America who to-day are superintendents of plantations or factories. Among those, too, who have been concerned with agricultural products and provisions is William Vincent Callery ('86), president of the Pittsburgh Provision and Packing Company. In addition, the present head of the American Hide and Leather Company is an alumnus. In another group of industries, now legally innocuous, typical manufacturers are the president of the Malted Grape Sugar and Syrup Company and the vice-president of the Welch Grape Sugar Company. Textiles, likewise—to bridge the gap fixed by the Tariff Commission—have appealed to the graduates, one of them, Leonard Hoskin ('41), having purchased and enlarged the Phoenix Cotton Mills, and another, John Wiley Griswold ('65), having organized the silk mills which bore his name. Finally, among pub-

lishers—listed ironically with printers—stands the president of John Wiley & Sons, of New York. Even without reference to the last schedule, containing sundries, it is clear that the alumni have entered almost every phase of industry.

To complete the picture, however, it is necessary to recall that there are many elements in an industrial society on which I have not touched. In such commonplace but essential matters as hotel accommodation the graduates have had a hand, controlling to-day two of the largest hostelries in New York and Chicago. In the realm of entertainment they have likewise done their part as owners or managers of several metropolitan theatres. Significant as are these facts, they are less significant than are those which reflect the applications of science to the intricacies of urban life.

In this connection I seem purposely to have avoided any reference to the great advance in electrical engineering during the last decade. Yet in this new and important field

the alumni have already established enviable reputations. The president of the Ontario Power Company and the vice-president of the Laurentide Power Company, two of the great corporations of the United States and Canada, are both graduates. In other branches—communication, for instance—they have been well abreast of their time. In the West, John Marshall Clark ('56) served as chairman of the Board of Directors of the Chicago Telephone Company, and, in the East, his classmate Josiah Phineas Davis ('56) became chief engineer of the Bell Telephone Company, now the American Telephone and Telegraph Company.

Similarly, any survey of the achievements of the alumni ought to include some reference to the activities especially connected with civil engineering. Instead of referring to the paving companies and to the firms which have specialized in the construction of filter plants or sewage disposal systems, I am going to turn, in conclusion, however, to a group of industries that will throw into relief the im-

portant part which the graduates have taken in the world of affairs. To-day the president of the Union Carbide and Carbon Corporation and the American Magnesium Corporation are both alumni. So too are, or were—for William Brown Cogswell ('51) is no longer living—the vice-presidents of the Aluminum Company of America and the Solvay Process Company. In his relationship to the latter firm, Cogswell symbolizes much that is typical in the careers of others who have studied in Troy. During the Civil War, he was drawn into the navy, serving as general superintendent of the repair shops on the Atlantic Coast. After his resignation he became interested in the salt and brine deposits near Syracuse. As a result of his studies in Europe, he arranged with Solvay et Cie., of Brussels, for the establishment of a branch in the United States. These negotiations led to the foundation of the present company, now the largest producer of soda in the world. Though Cogswell's career is an isolated instance, it is, as I have suggested,

sufficiently representative to warrant this conspicuous reference. In itself, it almost justifies what I have said regarding the influence of Rensselaer on the Industrial Revolution in the United States.

CHAPTER X

ENGINEERING EDUCATION

ALTHOUGH the aim of Stephen Van Rensselaer to train teachers to interpret the New Learning has been amply realized in the natural sciences, its early abandonment of agriculture and its subsequent emphasis upon industry have given the Institute a primacy in engineering education which it cannot claim in other fields. In the first century of its existence, approximately one hundred graduates have attained to professorial positions in the applied sciences. Influential as such a number would be under any circumstances, they have been especially influential because in many cases they have established the departments in which they have served. In the state universities, in the endowed institutions of the East, and in the technical schools founded since the Civil War, they have been a compelling force. A mere list of

their names would be almost an index to the history of engineering in the United States.

Since the first class in civil engineering was not graduated from the Institute until 1835; since Amos Eaton, who held the first chair of its kind in any English-speaking country, did not become professor until that time, and since the process of differentiation with which everyone is familiar did not begin until near the end of the nineteenth century, this history is still recent. The achievements of the alumni in the field of education, therefore, lead directly in many instances to the careers of men now living. In spite of this fortunate obstacle, it is not difficult to indicate the nature of their leadership in the development of the practical arts in the three types of institution mentioned in the last paragraph.

Because of conditions which I have already emphasized, their influence has been especially obvious in the state universities. In Michigan, as I have explained, the departments of botany, zoology, geology, mineralogy, and chemistry were established by

graduates of the Institute. They were responsible, moreover, for instruction in pharmacy, the theory and practice of medicine, and obstetrics and diseases of women and children as well as for the conduct of the library. In 1859, also, De Volson Wood ('57), professor of civil engineering, who served as professor of physics, and who, with President Tappan, had been directed by the Board of Regents to formulate a policy to govern the teaching of the sciences, organized a separate department of engineering, from which the first students were graduated in 1861. Among the records of the Board is a minute requesting him to draft a plate for the diploma. In Wisconsin, Ezra Slocum Carr ('38) and James Hall ('32) had been associated in the development of "natural history." In engineering they were seconded by another alumnus of the Institute. Their work as pioneers was paralleled, in Minnesota, by that of Arthur Beardsley ('67), who, in 1870, became professor of civil engineering and industrial mechanics. As such, he instituted the technical

departments of the university, outlining the courses from which the present curricula have gradually emerged. Elsewhere the tale is similar. In such universities as Arizona, Missouri, Texas, and West Virginia, in the United States, and Manitoba and New Brunswick, in Canada, and in colleges of agriculture, mechanics, and mining like Iowa, Louisiana, and Colorado, the alumni have been professors and deans, often responsible for the details of organization and administration.

In the colleges and universities of the East, they have been no less active. In Lafayette, Lehigh, Swarthmore, and Trinity, among the smaller colleges, they have been professors of civil, mechanical, and mining engineering. In Lafayette, Joseph Fox ('61), first professor of civil and topographical engineering, laid the foundations of its courses in the applied sciences. Among the other graduates of the Institute who served it at an early period was Justus Mitchell Silliman ('70), Markle professor of mining engineering. At Swarth-

more, which may well be cited in illustration of the formative character of the work done by the graduates of the Institute, Beardsley, leaving Wisconsin, became professor of applied mechanics, professor of mechanics and engineering, and, in 1885, in keeping with developments elsewhere, professor of civil and mechanical engineering. The first incumbent of the Williamson professorship of engineering, he established and directed the departments of the college dealing with the practical arts. His career is typical of that of the alumni who have entered the endowed universities. In the West, they organized departments in several institutions. In the East, at Columbia, Cornell, Harvard, New York, Pennsylvania, and Princeton, they have held professorships in engineering. Like most of the colleges founded under the Morrill Act, Cornell drew on Rensselaer not only in geology but also in engineering. In 1873 Estévan Antonio Fuertes ('61), who had already served as engineer-in-chief of the government expeditions to Tehuantepec and

Nicaragua to determine the practicability of a ship canal at the Isthmus, was elected dean of the school of engineering. Afterward professor of civil engineering and director of the college of civil engineering, as well as professor of astronomy, and constructor of the Barnes Observatory, he introduced in Ithaca many of the methods of instruction originated in Troy. To him the university is largely indebted for its excellent laboratories. At Harvard, Eben Norton Horsford ('38), first Rumford professor of the application of science to the useful arts in the Lawrence Scientific School, and founder of the department of chemistry, might almost be considered its first professor of engineering, anticipating, therefore, the distinguished alumnus who occupied a chair there later in the century. A somewhat similar relationship existed between James Curtis Booth ('31), professor of chemistry applied to the arts in the University of Pennsylvania, and Edgar Marburg ('85), for nearly thirty years professor of civil engineering and head of the

department. During this period the latter extended the curriculum and, with Professor Spangler, directed the construction of the admirably equipped building now occupied by the Towne Scientific School, in which his name is perpetuated by the Edgar Marburg Memorial Scholarship. Though services as great as his have been rendered by other men —in Princeton, for instance, where the first professor of civil engineering in the John C. Green School of Science was a graduate of the Institute—the character of their labors in the endowed universities ought, by this time, to be sufficiently clear.

On the technical schools, of course, the Institute has reacted even more powerfully. In this case, however, it does not seem necessary to refer to individual professors, such as Samuel Edward Warren ('51), of Massachusetts, or De Volson Wood ('57), of Stevens, both of whom were pathfinders in their respective fields. The example set by Rensselaer has been such a potent force in shaping the curricula of other institutions of the same

character that the achievements of even the most eminent teachers are easily overshadowed by it. Even a glance at the first courses offered by the Massachusetts Institute of Technology, founded in 1865, shows that, with a few exceptions, they were practically identical with those required at Rensselaer in the same year. The only striking difference is the larger place given at the Institute to botany, zoology, geology, and mineralogy. Since this parallelism occurs in connection with all institutions established after the Civil War, there appears to be no reason to qualify Dr. Charles Riborg Mann's conclusion that the report of Benjamin Franklin Greene ('42) must be ranked with the Industrial Revolution as one of the two stimuli that have directed the destinies of engineering education in the United States.

The influence of the Institute, however, has not been limited to professorships and curricula. Though it gave to Lafayette in the early days several teachers who shaped its courses in the applied sciences, two of its

sons, Ario Pardee, Jr. ('58), and Calvin Pardee ('60), both of whose names will be commemorated by the dormitory now being erected at Rensselaer, were among its greatest benefactors. Indeed, in all matters pertaining to the advancement of engineering as a profession, the alumni have taken a lively interest. Wood, for example, served as first president of the Society for the Promotion of Engineering Education. Richard Pennefeather Rothwell ('58), as I have pointed out, organized the American Institute of Mining Engineers. In 1892, also, there were in the American Society of Civil Engineers—the chief technical association of the continent—four times as many graduates as from any other institution and as many as from any five other schools or colleges combined. Of fourteen members who to-day have been connected with the organization for half a century or more, five are alumni of the Institute. Through such professional contacts alone, its indirect influence upon the development of engineering education has been

enormous. Nor has its influence been restricted to the United States. In Japan it has given two professors of civil engineering to the Imperial University, at Tokio; in China it has provided a director for the department in the Imperial University, at Tientsin; and among its graduates—nearly two hundred—from the countries of Latin America, a number have devoted themselves to the problems of education. A few like Fuertes, of Cornell, have remained in the North; but most of them have returned to their homes to duplicate there the foundations laid in Troy a century ago by Amos Eaton and Stephen Van Rensselaer.

EPILOGUE

THOUGH I began this sketch as a memorial of the hundredth anniversary of the establishment of the Institute, I soon found that it was likely to throw no little light upon certain phases of scientific and technical education in the United States. The reason is obvious.

Rensselaer was established in 1824. The Lawrence Scientific School, at Harvard, and the Sheffield Scientific School, at Yale, were not founded until 1847. Massachusetts did not open until 1865, Worcester, Stevens, and Case following in 1868, 1871, and 1881. Among the state universities, Michigan laid the cornerstone of its college of engineering and architecture in 1853; but Illinois and Minnesota—other beneficiaries of the Morrill Act—were not organized until 1868, and Wisconsin did not inaugurate its courses in technology until 1870. Though all these institutions except Yale are legitimate offspring of the Institute, having been founded by its graduates or moulded after the patterns

which it had framed, I want to emphasize not their origin but their youth. Since the number of students graduated from the Lawrence Scientific School and the Sheffield Scientific School before the Civil War was relatively small, and since more scientists and engineers—both teachers and practitioners—had been graduated from Rensselaer than from all the universities, the records of its alumni are especially significant. Through them it is possible to trace the careers of a group of men educated in the New Learning whose work can now be seen in true perspective. Such a group cannot be found among the graduates of any other institution. In view of the present investigation of the Society for the Promotion of Engineering Education, the results of this survey are of more than passing interest.

One of the most striking facts is the range of the services rendered by the alumni. There is no activity in which they have not engaged. Since civilization is becoming more responsive to the demands of industry, it is

inconceivable that there will be any restriction of their interests in the future. Indeed, it is safe to predict that students seeking to adjust themselves to their environment will turn in increasing numbers to the schools of engineering which do not overlook the lesson to which this study seems to point. Its implications are unescapable. Since the alumni of the Institute have been drawn, and evidently will be drawn, into every field of human endeavor, and since conditions elsewhere are doubtless the same, undergraduate courses everywhere ought to remain distinctly general. Though they must be orientated toward architectural, civil, chemical, electrical, mechanical, or mining engineering, they should nevertheless contain the elements of a sound and liberal education.

On the other hand, there must be provision for advanced and highly specialized study. Any one who is inclined to doubt the value of education ought to follow the path which I have taken in the last six months. Among the alumni whose careers have been com-

pleted, a surprisingly large number of those who have achieved success were not content with the limits of the traditional four-year course. Any one who has read the preceding pages will recall that many whom I have mentioned came to Rensselaer from other institutions. Some, like Alfred Pancoast Boller ('61) and Nelson Peter Lewis ('79), had received degrees in arts before matriculation. Others, like Alexander Johnson Cassatt ('59), who had studied at the universities of Heidelberg and Darmstadt, and William Newton Symington ('61), had enjoyed advantages that were no less solid even if they were less orthodox. In the early period, when the courses in Troy represented the highest development in applied science, the leaders were often found among the men who had turned to the Institute after such preliminary training. In fields where it was not supreme, they were to be found, as a rule, among those like James Curtis Booth ('31), in chemistry, and Richard Pennefeather Rothwell ('58), in mining, who had extended their knowledge in the

great schools of Europe. Even after due allowance has been made for the imponderable factors of ability, ambition, and opportunity, it is clear that distinction in any phase of science or engineering bears a definite relation to the character of the education which has preceded it. If this conclusion is sound—and it can easily be substantiated by the training of the men who to-day are influencing the course of civilization—it is obvious that not a few pathfinders will be found hereafter among the students who become candidates for higher degrees. For this reason the Institute has recently provided a graduate curriculum to supplement each undergraduate curriculum. What it did in the early days, through its undergraduate courses, it hopes to do in the future not only through them but also through its graduate courses as well.

What I have said leads to another subject. The president of a great university which I hold in affectionate regard has recently appealed for a considerable sum for its depart-

ment of chemistry. In his appeal he has properly stressed the value of research and the importance of an atmosphere conducive to intellectual attainment. Though it is true, as he points out, that a member of a university faculty has many opportunities for matching opinions with colleagues in other fields, these opportunities, as every one knows, are potential only. In the busy routine of academic life, a specialist naturally finds his chief and sometimes his only companionship among those who are concerned with similar problems. In practice, the conditions under which any investigator works are much the same whether his lot is cast in the fellowship of a university or a technical school. At any rate, there is no reason why the spirit of pure scholarship, essential to progress, should not flourish in one institution as well as in the other. In Rensselaer, at any rate, whatever may be the situation elsewhere, it has always existed. The names of Samuel Wells Williams ('32), in philology; of Asa Fitch, Jr. ('27), in entomology; of James Hall ('32), in

geology; of James Curtis Booth ('31), in chemistry, and of Henry Augustus Rowland ('70), in physics, are sufficient proof that in the past the Institute has looked beneath the forces which it has applied to the principles which underlie them. To-day, moreover, a committee of the faculty engaged upon a study of the course in general science is anxiously exploring the avenues by which it may provide the most thorough instruction in mathematics, physics, and chemistry for students who may be attracted by these subjects.

Even though I have insisted upon the place of these sciences, I fear that some educators may regard this sketch as a sop to the Philistines. They may challenge the value of the disciplines to which the Institute is committed. To its graduates they may apply the final test of character. To such pragmatism I do not object. All discussions of this kind, however, are marred by one serious defect. In every contrast between the personalities and achievements of those who have been trained in a classical tradition and those who

have been moulded by another system, it is customary to compare the few members of the first group who represent the rich vintage of the ages with the members of the second group as a whole. Any such procedure is misleading and unfair. Since I have been at Rensselaer, I have had an opportunity to study boys whose fathers, grandfathers, and even great-grandfathers have been graduated from the Institute. Among them are to be found the highest types of manhood. This fact ought to hearten the educators who have seen the landmarks of their youth—the pillars in which they have put their trust—submerged by a flood of frank utilitarianism. Doubtless it has carried along with it much useless débris. Doubtless, too, it has absorbed a deal of flotsam that is rank and unwholesome. Nevertheless, like other streams, it will finally emerge as pure and serene as those which once lapped the channels which it has preempted.

Of the new civilization, of which it is a symbol, Rensselaer was the first exponent.

Though it is not the largest or the wealthiest institution devoted to "the common purposes of life," it will always be the oldest. In a peculiar way the last century has been its own. Though there are many developments in engineering which it cannot claim, the essential features of every technical school have sprung from its experience. To-day there are in the United States over one hundred and thirty colleges or departments of applied science. In view of their number, it is not probable that any one of them will assume in the future the position held by Rensselaer in the past. It seems likely that progress will depend upon concerted action instead of individual initiative. The present survey by the Society for the Promotion of Engineering Education is sufficient evidence of the trend toward coöperation. Nevertheless, whatever may be the nature of its conclusions, they are certain to reflect to some extent the ideals which dominated Amos Eaton and Stephen Van Rensselaer in 1824.